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SUPPURATION OF THE PETROUS PYRAMID

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A review of the literature on suppuration of the petrous pyramid reveals the fact that the symptoms and signs now associated with this condition were known to pioneer otologists.

The modern concept of the disease is the result of gradual development which began with the classic description of the symptom complex by Gradenigo [1] in 1904 and again in 1907. Since that time the interest of otologists in this condition has been constant. The excellent contributions of Perkins [2] in 1910 and of Sears [3] in 1926 have intensified this interest. The number of articles which have appeared in the recent literature evidences the increasing attention which the subject has received during the past few years. Unfortunately, numerous divergent views have been expressed with regard to the symptomatology, the pathology, the prognosis and the treatment. Considerable confusion and numerous misconceptions have thus arisen.

In an attempt to clarify various aspects of the subject we are presenting a report on the clinical and histologic material studied at the Mount Sinai Hospital during the past seven years, together with a review of the literature. Our report is composed almost entirely of observations on acute cases.

REVIEW OF THE LITERATURE

Involvement of the Sixth Nerve.—Following the publication of Gradenigo's original paper the significance of paralysis of the abducens

From the Otologic Service and the Department of Laboratories of the Mount Sinai Hospital.

1. Gradenigo, G.: Ueber circumscripte Lepto-meningitis mit spinalen Symptomen und über Paralyse des Nervus Abducens otitischen Ursprungs, Arch. f. Ohrenh. **62**:255, 1904.

2. Perkins, C. E.: Gradenigo Syndrome, Ann. Otol., Rhin. & Laryng. **19**:692, 1910.

3. Sears, W. H.: Otogenic Paralysis of the Abducens Nerve, Ann. Otol., Rhin. & Laryng. **35**:348, 1926.

nerve was extensively studied, and many theories were advanced to explain the causal mechanism. The diversified views that have been advanced are of theoretical interest but, as Brunner [4] remarked, are of scant practical importance. Many observers have stated that paralysis of the abducens nerve is not a constant sign of deep-seated inflammation of the petrous pyramid. Lange,[5] Voss,[6] Haberman,[7] Uffenorde,[8] Ulrich,[9] Grünberg,[10] Engelhardt,[11] two of us (I. F. and J. G. D.) [12] and others have reported cases in which an abscess was noted in the apex of the pyramid without clinical signs of involvement of the abducens nerve. Jansen [13] described an instance of widespread destruction at the petrous apex that extended 3 mm. from the internal auditory meatus to the body of the occipital bone, anteriorly to the carotid canal and below to the floor of the skull, without paralysis of the abducens nerve. Nager [14] reported a case of suppuration of the petrous pyramid with paralysis of the abducens nerve in which operation revealed an extradural abscess in the region of the saccus. In a previous communication we called attention to the fact, based on our histologic studies, that perforation of the petrosal cortex may take place anywhere along its surfaces and not necessarily in the region of the apex. Perforations lateral to the apex may also give signs of involvement of the trigeminal and abducens nerves. Since paralysis of the sixth nerve may occur with otitis, as Gradenigo originally reported, and since it may be absent

4. Brunner, H.: Ueber eitrige Erkrankungen an der Felsenbeinspitze, Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:383, 1930.

5. Lange, W.: Zur Pathologie tief gelegener epiduraler Abzesse ohne Labyrinthentzündung, Beitr. z. Anat. Physiol., Path. u. Therap. d. Ohres **2**:162, 1908; Tiefgelegene Entzündungsherde im Schläfenbeine, Ztschr. f. Hals-, Nasen- u. Ohrenh. **32**:99, 1932.

6. Voss, O.: Pyramidenspitzeneiterungen (Petrositis) an der Hand von 12 selbstbeobachteten Fällen, Acta oto-laryng. **15**:469, 1931.

7. Haberman, J.: Ueber Erkrankungen des Felsenteiles und des Ohrlabyrinths, Arch. f. Ohrenh. **42**:128, 1897.

8. Uffenorde, W.: Zur Klinik der Fälle von Mittelohreiterung mit tiefen perilabyrinthären Herden, Arch. f. Ohrenh. **105**:87, 1920.

9. Ulrich, K.: Zur Lehre von der otogenen Abducenslähmung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **9**:403, 1924.

10. Grünberg, K.: Zur Pathogenese tief gelegener epiduraler Entzündungsherde im Felsenbein, Ztschr. f. Ohrenh. **75**:66, 1917.

11. Engelhardt, G.: Ueber otogene durch perilabyrinthäre Herde vermittelte tiefe extradurale Abscesse, Beitr. z. path. Anat. u. z. allg. Path. **71**:645, 1923.

12. Friesner, I., and Druss, J. G.: Osteitis of the Petrous Pyramid, Arch. Otolaryng. **12**:342 (Sept.) 1930. Druss, J. G.: Anatomy and Pathology of Petrositis, Laryngoscope **41**:394 (June) 1931.

13. Jansen, A.: Zur Kenntnis der durch Labyrintheiterung induzierten, tiefen, extraduralen Abscesse in der hinteren Schädelgrube, Arch. f. Ohrenh. **35**:290, 1893.

14. Nager, F. R.: Zur operativen Behandlung an der Felsenbeinspitze (Gradenigoschen Symptom-Komplex), Versamml. Gesellsch. Schweiz. f. Hals-, Nasen- u. Ohrenärzte in Genf. **6**:1, 1932.

with severe disease in or about the petrous pyramid (extradural abscess, meningitis) it is obvious that no conclusions as to diagnosis or therapy can be made solely from the presence or absence of paralysis of the abducens nerve.

Involvement of the Trigeminal Nerve.—In the diagnosis of suppuration of the pyramid Engelhardt,[11] Schlander,[15] Mayer,[16] Brunner [4] and others have repeatedly emphasized the significance of pain caused by the trigeminal nerve. As far back as 1869 von Tröltsch [17] observed two cases in which severe pain in the face developed in the course of chronic suppuration of the middle ear. He expressed the belief that he had found the explanation of this unusual symptom in the histologic sections made in a third case in which the region of the tip of the petrous pyramid and the gasserian ganglion showed definite evidence of disease. Moos [18] in 1876, Kipp [19] in 1879, Urbanschitsch [20] in 1880, Bürkner [21] in 1883, Schmiegelow [22] in 1888 and Bircher [23] in 1893 described cases which demonstrated the association of severe pain in all branches of the trigeminal nerve in acute and in chronic disease of the ear. From the description of their cases and in the light of present knowledge, we believe that they were probably dealing with suppuration of the petrous pyramid. Ostman [24] in 1897 noted constant supra-

15. Schlander, E.: Zur Histologie der Eiterungen, der Pyramidenspitze, Ztschr. f. Hals-, Nasen- u. Ohrenh. **12**:492, 1925; Otitis Media acuta mit Spitzsymptomen, Monatschr. f. Ohrenh. **62**:492, 1928.

16. Mayer, O.: Gradenigoische Symptomenkomplex bei akuter Mittelohreiterung: Operative Freilegung und Eröffnung eines Abscesses an der Pyramidenspitze in der Nähe des Bulbus venae jugularis; Heilung, Monatschr. f. Ohrenh. **63**:970, 1929.

17. von Tröltsch, A. F.: Anatomische Beiträge zur Lehre von der Ohr-Eiterung, Arch. f. Ohrenh. **4**:126, 1869.

18. Moos, S.: Ueber den Zusammenhang zwischen Krankheiten des Gehörorgans und solchen des Nervus Trigeminus, Virchows Arch. f. path. Anat. **68**: 433, 1876.

19. Kipp, C. J.: Vier Fälle von intracraniellen Krankheiten von chronic eitriger Mittelohrentzündung, Heilung in zwei Fällen: Todesfalle zwei, Ztschr. f. Ohrenh. **13**:283, 1879.

20. Urbanschitsch, E.: Lehrbuch der Ohrenheilkunde, Leipzig, Urban & Schwarzenberg, 1880.

21. Bürkner, K.: Drei Fälle von tödlich verlaufenen Ohrleiden nebst Beiträgen zur pathologischen Anatomie des Gehörorgans, Arch. f. Ohrenh. **19**:250, 1883.

22. Schmiegelow, E.: Einige seltene Fälle von Erkrankungen des Mittelohrs die mit endocraniellen Leiden compliciert waren, Arch. f. Ohrenh. **26**:84, 1888.

23. Bircher, H.: Phlebitis der sinus transversus petrosis inferior und cavernosus, Eröffnung und Desinfektion nach Entfernung der Felsenbeinpyramide: Heilung, Centralbl. f. Chir. **20**:483, 1893.

24. Ostman: Ueber die Beziehungen zwischen Auge und Ohr, Arch. f. Ophth. **43**:1, 1897.

orbital, infra-orbital and deep ocular pain in cases of involvement of the petrous pyramid with inflammatory changes in the region of the gasserian ganglion. Streit [25] in 1902 described the ocular pain and pointed out its occurrence in cases of suppuration of the petrous pyramid associated with extradural abscess (case 15).

In Gradenigo's original communication in 1904 no special mention was made of the significance of pain in the eye. He stressed temporal headache. The explanation was generally accepted that the pain above, about and in the eye was due to irritation of the ophthalmic branch of the gasserian ganglion. Ramadier,[26] dissatisfied with this explanation of the mechanism of the ocular pain, stated that he could not understand how it was possible that the ophthalmic division alone could be affected when the focus of osteitis was in relation to other portions of the trigeminal nerve. Eagleton [27] expressed the opinion that the ocular pain was due to irritation of the ophthalmic nerve caused by stretching of the nerve or by its adhesion to the dura. It is a curious fact, however, that the pain should be confined to a relatively small portion of the area supplied by the nerve. It seems logical to expect that when a nerve is stimulated or irritated the stimulus should be referred over its entire range of distribution. Vail [28] has expressed the opinion that the ocular pains associated with suppuration of the petrous pyramid are caused by irritation of the great superficial petrosal nerve. Vogel [29] stated that many of the nerve fibers leave the sphenopalatine ganglion and terminate in the sphenomaxillary fossa, in the periosteum of the posterior portion of the sphenoid, in the periorbital area and in the infra-orbital fissure, where they communicate with branches of the trigeminal nerve. One can therefore readily understand Sluder's [30] statement that the typical ocular pains of sphenopalatine neuralgia are also typical of and indistinguishable from those of petrositis. It is difficult to reconcile some of the theoretical explanations of the ocular pain

25. Streit, H.: Weitere Fälle endocranieller Komplikationen akuter und chronischer Mittelohreiterung, Arch. f. Ohrenh. **56**:178, 1902.

26. Ramadier, J.: L'ostéité profonde du rocher, Ann. d'oto-laryng., Dec., 1931, p. 1300.

27. Eagleton, W. P.: Sixth Nerve Involvement in the Diagnosis and Surgical Treatment of Meningitis of Otitic and Nasal Origin, Compt. rend. Cong. internat. d'oto-rhinolaryng., 1928, p. 824.

28. Vail, H. H.: Vidian Neuralgia with Special Reference to the Eye and Orbital Pain in Suppuration of the Petrous Apex, Arch. Otolaryng. **17**:212 (Feb.) 1933.

29. Vogel, K.: Die Beziehung des Ganglion sphenopalatinum zu den von ihm ausgehenden Nervenstämmen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:435 (March) 1930.

30. Sluder, G.: Etiology, Diagnosis, Prognosis and Treatment of Sphenopalatine Ganglion Neuralgia, J. A. M. A. **61**:1201 (Sept. 27) 1913.

noted clinically with the observations made on histologic examination. Uffenorde,[31] Hilgerman [32] and Brunner [4] found histologic evidence of extensive purulent infiltration of the entire gasserian ganglion in cases of petrositis in which there was no pain. Severe pain deep in the eye has been reported in cases of suppurative sphenoiditis by Vail,[28] Eagleton,[27] Fox [33] and others and in cases of osteitis of the zygoma by Retjö,[34] Hamilton,[35] two of us (H. R. and J. G. D.) [36] and others.

Kopetsky and Almour [37] stated that after the initial onset of pain in the eye, otorrhea and low grade sepsis the condition in some cases enters a second stage, one of quiescence, which is coincident with the advance of the infection into the epidural region about the petrous apex. They stated that one should not be deceived by apparent recovery but should drain the petrous apex before the onset of meningitis. In discussing the pain in cases of petrositis Cavanaugh [38] expressed the belief that pain should persist rather than disappear when perforation through the cortex takes place, since pus and the inflammatory condition of the dura remain. Sunde [39] expressed the belief that it is just as logical to assume in these instances that the patient is actually recovering and that the pus had broken through into the middle ear by means of the chain of cells through which the infection first entered the petrous pyramid.

The cardinal symptom of an epidural abscess is pain. In ten of the eleven cases of epidural abscess in which the temporal bones were examined histologically, headache was present; furthermore, three of our patients operated on for epidural abscess had pain. Finally, in the cases in which there was spontaneous cure the cessation of pain was in all but one instance an accompaniment of beginning recovery.

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31. Uffenorde, W.: Eine zu vielfachen Verwicklungen führende sehr ausgedehnte perilabyrinthäre Eiterung im histologischen Bilde, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **122**:288, 1929.

32. Hilgerman, R.: Die Beteiligung des Ganglion Gasseri bei Mittelohreiterungen, Ztschr. f. Ohrenh. **40**:311, 1901-1902.

33. Fox, C. C.: Sinus Headache, Arch. Otolaryng. **20**:813 (Dec.) 1934.

34. Retjö, A.: Ueber zwei Fälle von Abduzenslähmung bei akuter Mittelohrentzündung, Monatschr. f. Ohrenh. **67**:1247, 1933.

35. Hamilton, E. S. B.: A Case of Gradenigo Syndrome, J. Laryng. & Otol. **43**:43 (Jan.) 1928.

36. Rosenwasser, H., and Druss, J. G.: Zygomatic Infections as a Factor in Otitic Complications, Arch. Otolaryng. **17**:625 (May) 1933.

37. Kopetsky, S., and Almour, R.: Suppuration of the Petrous Pyramid, Ann. Otol., Rhin. & Laryng. **39**:996, 1930.

38. Cavanaugh, J. A., in discussion on Ballenger, H.: Petrositis, Arch. Otolaryng. **17**:728 (May) 1933.

39. Sunde, E.: Infection of the Petrous Bone, Arch. Otolaryng. **19**:436 (April) 1934.

Significance of the Roentgen Examination.—In recent years there has been great interest in the roentgenogram as an aid in the diagnosis of petrositis and in the indications for therapy. Among the earlier contributors were Baldenweck and de Prades,[40] who, in 1927, found roentgen evidence of obliteration of the apex of the petrous pyramid, associated with involvement of the fifth and sixth nerves. Neumann [41] in 1928 reported the following interesting case:

A 38 year old man with a three month history of otitis and headache was operated on, and mastoiditis due to Pneumococcus type III in a well pneumatized mastoid process was found. The immediate postoperative course was uneventful. Fourteen days later, however, periorbital pain and photophobia developed, and on the following day, paralysis of the abducens nerve. The temperature rose, and there was a recurrence of the otitis. Roentgen examination revealed "pneumatized petrous pyramid, destructive process in the apex. . . ." After repeated paracentesis and recurring discharge the patient made an uneventful recovery.

Schlander [15] related the following history:

A 28 year old patient had acute otitis and homolateral neuralgic headache. After three weeks of otitis the roentgen findings were: "extensive pneumatization, the mastoid cells are hazy, the apex of the pyramid is markedly absorbed." At operation, softened bony septums and pus were found in the mastoid process. Four weeks after the operation the roentgen report was as follows: "One can definitely see now that the destruction extends to the internal auditory meatus and above to the superior semi-circular canal. The labyrinthine capsule is uninvolved." Eight weeks after operation, the roentgen findings showed that "the contour of the pyramidal apex was normal. Within the pyramid however no bony structure could be recognized."

In this case the roentgenograms at first showed extensive changes in the petrous apex and later the process of healing, while clinically only relatively mild symptoms of involvement of the fifth nerve were present. The sixth nerve was unaffected.

Schlander,[15] Neumann,[41] Mayer and Eisinger [42] and van Voorthuyssen [43] have described cases in which definite roentgen evidence of severe inflammatory changes in the apex of the pyramid were present but recovery followed paracentesis or simple mastoidectomy. In van Voorthuyssen's case the roentgenogram was interpreted to indicate solution of continuity of the dural plate. None of these authors believed that the roentgen changes associated with the so-called Gradenigo syndrome in cases of pneumatized pyramids should in themselves indicate surgical intervention.

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40. Baldenweck, L., and de Prades: Application de la radiographie du rocher à l'étude du syndrome de Gradenigo, Acta oto-laryng. **11**:244, 1927.

41. Neumann, H.: Mukosusotitis mit Spitzensymptomen, Monatschr. f. Ohrenh. **62**:490, 1928.

42. Mayer, E. G., and Eisinger, K.: Otologische Roentgendiagnostik, Berlin, Julius Springer, 1930, p. 308.

43. van Voorthuyssen, D. G. W.: On the Origin and Development of Gradenigo's Syndrome, Acta otolaryng. **18**:265, 1933.

Among other observers who have reported cases in which there was a destructive process in the petrous apex visible roentgenologically and associated with what the authors termed the Gradenigo syndrome with recovery without operation on the petrous pyramid are Agazzi,[44] Podestà [45] and Piquet.[46] Lemaitre and Aubin [47] reported two cases in which there was typical involvement of the fifth and sixth nerves and in which roentgen examination showed definite haziness of the region of the petrous apex. The patients recovered following simple mastoidectomy. Bigler,[48] Whitham,[49] Burger,[50] Taylor,[51] Arnoldson,[52] Epstein,[53] Olsson,[54] Nager [55] and Dohlman [56] have reported their various experiences with roentgen observation in cases of suppuration of the petrous pyramid and have stated their conclusions as to its significance and their recommendations.

Dohlman expressed the opinion that even with very good technic one cannot always be certain that what seems to be dissolution of bone in the roentgenogram is a process which is significant as an indication for operation. This view was amply supported by Coates, Ersner and Myers,[57] who recently reported a series of nine cases of petrositis in

44. Agazzi, B.: Sull' importanza dell' indagine radiologica nella sindrome di Gradenigo, Zentralbl. f. Hals-, Nasen- u. Ohrenh. **12**:355, 1928.

45. Podestà, E.: Per la sindrome di Gradenigo, Ann. di laryng., otol. **29**:65 (March) 1928.

46. Piquet, J.: Ostéite pétreuse profonde, Zentralbl. f. Hals-, Nasen- u. Ohrenh. **21**:727 (Dec.) 1933.

47. Lemaitre, F., and Aubin, A.: Deux cas de syndrome de Gradenigo, Arch. internat. de laryng. **33**:977, 1927.

48. Bigler, M.: Zur röntgenologischen Darstellung eines Knochenabscesses in der Felsenbeinspitze beim Gradenigoschen Symptomenkomplex, Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:249, 1930.

49. Whitham, J. D.: Mastoiditis with Gradenigo Syndrome Before Operation: Mastoiditis with Gradenigo Syndrome After Operation, Laryngoscope **37**:368, 1927.

50. Burger, H.: Die röntgenographische Diagnose des Symptoms von Gradenigo, Acta oto-laryng. **17**:353, 1932.

51. Taylor, H. K.: Suppuration of the Petrosal Pyramid: Roentgenologic Problems, Arch. Otolaryng. **18**:458 (Oct.) 1933.

52. Arnoldson, N., in discussion on Dohlman.[56]

53. Epstein, H.: Röntgenologische Beiträge zum Gradenigoschen Symptomenkomplex, Ztschr. f. Hals-, Nasen- u. Ohrenh. **21**:490, 1934.

54. Olsson, Y.: Un cas de ostéite de la pyramide (du temporal) démonstrée par la radiographie, Acta oto-laryng. **18**:163, 1932.

55. Nager, F. R.: Die Bedeutung der Roentgenuntersuchung bei den Eiterungen der Felsenbeinspitze, Acta radiol. **15**:475, 1934.

56. Dohlman, G.: What Can X-Ray Examination Contribute at Present in Acute and Chronic Otitis? Acta oto-laryng. **20**:471, 1934.

57. Coates, G. M.; Ersner, M., and Myers, D.: Roentgen Changes in the Petrous Portion of the Temporal Bone Without Clinical Manifestations, Arch. Otolaryng. **20**:615 (Nov.) 1934.

which roentgen studies indicated well pneumatized pyramids. They treated all their patients by conservative surgical measures, paracentesis or simple mastoidectomy, except in one instance in which the Almour [58] procedure yielded negative findings. All their patients recovered.

"From the standpoint of the otologist," said Dohlman, "the most important thing to know is whether any complications exist or are in process of developing, and roentgenograms can give no information as to this." In conclusion, one may say that in the vast majority of cases the interpretation of serial roentgenograms constitutes only one step in the ladder of critical investigation of patients suffering from suppuration in the petrous pyramid. Positive roentgen findings alone do not constitute an indication for surgical intervention.

PATHOLOGY

Before presenting the histopathologic changes noted in our cases of suppuration of the petrous pyramid we believe that it is of considerable importance to emphasize the following facts: Suppuration of the petrous pyramid has been noted histologically in a large number of patients who died of otitic intracranial complication. In these patients there was no clinical evidence at any time, or even a basis for suspicion, that such a condition existed. It was noted accidentally in the routine examination of our material. Even in retrospect, it is at times difficult or impossible to correlate the clinical with the histologic observations. Nevertheless, the fact remains that there are cases of suppuration of the petrous pyramid (histologically) in which, so far as we were able to ascertain, there are neither typical clinical signs nor typical symptoms of the condition. Furthermore, there is no doubt that in the early stages of acute suppuration of the middle ear there may be an associated involvement not only of the pneumatic spaces in the mastoid but also of the cells in the petrous pyramid. The inflammatory involvement may take place simultaneously with the onset of the otitis media or may follow shortly thereafter. The inflammatory changes in the pneumatic spaces at this stage may vary from thickening and infiltration of the mucosa to an extravasation of purulent exudate. These changes may be present without characteristic signs or symptoms.

In the consideration of petrositis it is of importance to include pathologic changes which occur not only in the apex but in the perilabyrinthine structures. Thus, cases have been reported in the literature in which the condition was termed perilabyrinthitis and deep extradural abscess when in reality it should be considered as petrositis. It

58. Almour, R.: Surgical Therapy for Relief of Suppuration of Petrous Pyramid, Laryngoscope **41**:405, 1931.

also must not be forgotten that by no means in all cases does the lesion in the petrous pyramid extend to the apex, nor are the symptoms dependent on an extension of the lesions to the apex.

In twenty-four cases in which the temporal bone was sectioned serially a histologic diagnosis of petrositis was made. In twenty of these the sections were made up to the extreme tip of the apex. We have not included in our series a number of cases in which the patient died of otitic intracranial complications and in which such mild inflammatory changes were noted in the petrous pyramid as thickening of the mucosa of the perilabyrinthine cells or slight exudation.

Of the twenty-four cases of petrositis the mastoid process was pneumatic in twelve (50 per cent), mixed in nine (37½ per cent) and diploic in three (12½ per cent). The petrous pyramid was pneumatic in four cases (16⅔ per cent), mixed in eighteen (75 per cent) and diploic in two (8⅓ per cent). Of the twenty cases in which the apex was sectioned it was pneumatic in one (5 per cent; fig. 1) mixed in six (30 per cent; fig. 2) and diploic in thirteen (65 per cent). A résumé of the observation is given in the tabulation.

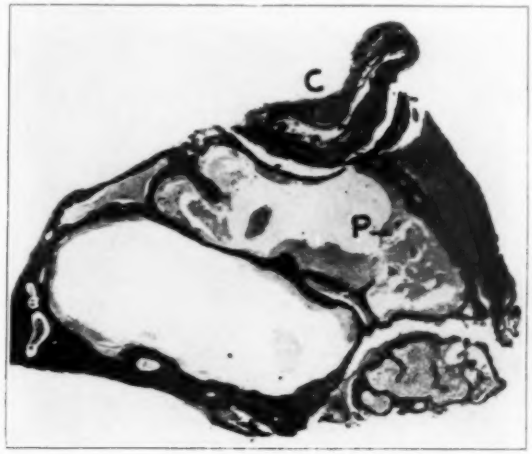

Fig. 1.—A vertical section through the apex showing extensive pneumatization. Purulent exudate (*P*) is present within the cells. *C* indicates the carotid artery.

Process	Pneumatic	Mixed	Diploic
Mastoid	12	9	3
Petrous pyramid	4	18	2
Apex	1	6	13

It must be borne in mind that in the determination of the type of anatomic structure of the temporal bone no definite criteria have been

established and the personal interpretation of the observer is an important factor. The age of the patient must also be taken into account in considering pneumatization of the temporal bone. The completion of pneumatization of the petrous apex takes place at a later period than it does in the mastoid. In the twenty cases in which the apex was sectioned ten (50 per cent) of the patients were under 10 years of age. This may account for our large percentage (thirteen of twenty) of diploic apexes.

While we are aware that no definite conclusion can be drawn from so small a series of cases, the findings were nevertheless extremely suggestive. This is particularly true in view of the fact that the foregoing

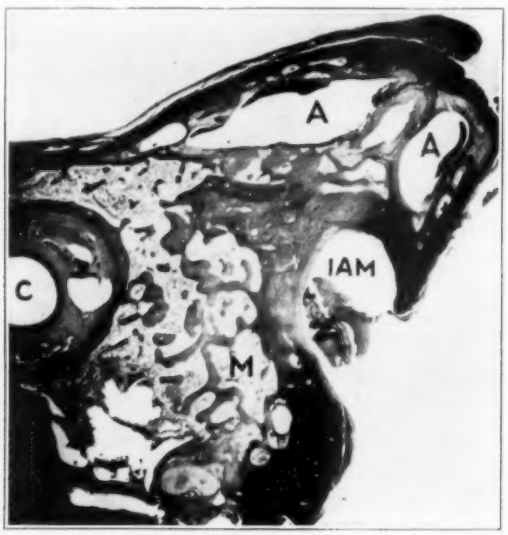

Fig. 2.—A vertical section through the apex showing both large pneumatic cells (*A*) above the internal auditory meatus (*IAM*) containing purulent exudate and a large area of bone marrow (*M*). *C* indicates the carotid artery.

tabulation was made from a histologic study of serial sections. Here the chances of error are lessened, and the factor of personal interpretation does not play so great a rôle. The figures obtained from the literature up to the present time were based mainly on gross observations made on temporal bones. As we stated previously, the greater the degree of pneumatization in the temporal bone the greater is the facility with which infection spreads through it.

From the figures it can be stated that pneumatization is present much more frequently in the mastoid than in the petrous pyramid and the apex. In isolated instances the pneumatization in the petrous pyramid may be more advanced than that in the mastoid process. Thus, in the classifi-

cation of our own series the figures in the second column (mixed type) of the tabulation indicate the more frequent presence of some pneumatic structure in the petrous pyramid than in the mastoid bone. This may be accounted for by the fact that the process of pneumatization extends from the tympanic cavity and eustachian tube into the petrous pyramid and apex. This process may continue after pneumatization in the mastoid has terminated.

Various routes of extension from the tympanum and antrum have been previously described by others as well as by some of us. In the majority of cases infection spreads from the tympanum and antrum along the perilabyrinthine cells (supralabyrinthine, postlabyrinthine, anterolabyrinthine along the eustachian tube and sublabyrinthine cells). These groups of cells communicate with each other, and none but an arbitrary division can be made. The infectious process as it advances in its course may involve adjacent marrow spaces and the more dense bone. In the strict sense of the term osteitis is not always present. Instead, the picture is that of a combination of osteitis and osteomyelitis. While this is true for the mastoid, it is obvious from the figures in the tabulation that the condition occurs frequently in the petrous pyramid and the apex.

PATHWAYS OF INFECTION

Since no definite lines of demarcation separate the various groups of perilabyrinthine cells and since the extension may take place along more than one route, it is at times difficult to determine even by histologic study the exact pathway of extension. In the instances in which the infection involved the entire perilabyrinthine group of cells or a considerable portion of them we have identified the pathway through which the infection extended by determining the area in which the maximum inflammatory change and destruction occurred.

In nineteen of the twenty-four cases the infection spread from the tympanum and antrum along the superior and posterior perilabyrinthine structures (fig. 3). In some of these cases, however, the infralabyrinthine cells were involved. In fourteen cases the supralabyrinthine route of extension was predominant. The infralabyrinthine route was predominant in two cases (fig. 4). In two cases the infectious process extended through the subarcuate fossa and in one of these the fossa was the predominant pathway of extension. In three cases extension took place mainly along the peritubal cells, and in two, the infection extended along the carotid canal. In two cases the route of extension could not be determined with any degree of accuracy.

Thus, we found that the posterosuperior route was by far the most frequent. It cannot be stated too emphatically that not all lesions in the petrous pyramid extend to the apex. In the majority of our cases the

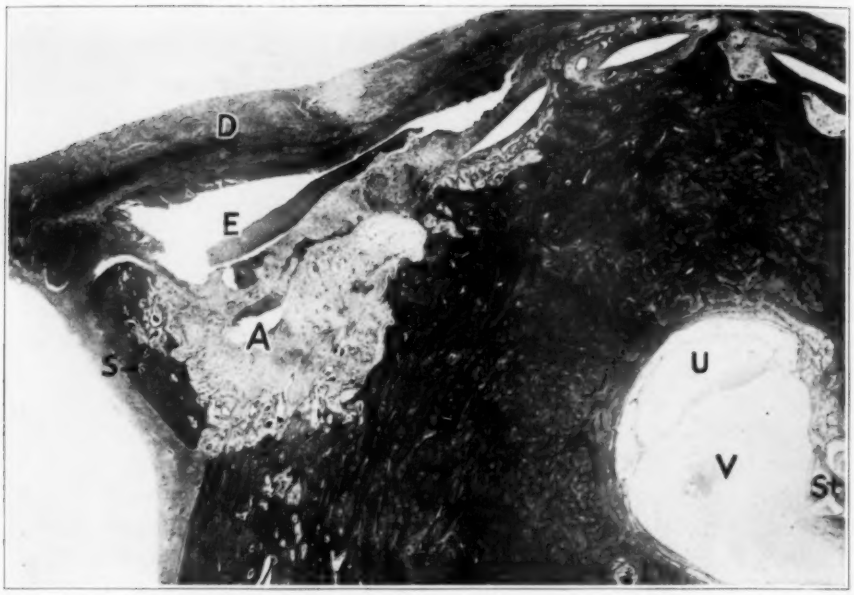

Fig. 3.—A section showing an area of osteitis (*A*) of the superoposterior margin of the petrous pyramid with sequestration of bone (*S*) and the formation of an extradural abscess (*E*) at the middle and posterior fossae. *D* indicates the markedly thickened dura; *V*, the vestibule; *U*, the utricle, and *St*, the stapes.

Fig. 4.—A section showing an area of osteitis (*A*) in the region of the jugular bulb below the labyrinth. Labyrinthitis is present. *C* indicates the cochlea; *E*, the eustachian tube; *IAM*, the internal auditory meatus, and *F*, the facial nerve.

greatest expression of the disease process was noted in the petrous pyramid between the superior semicircular canal and the internal auditory meatus. Furthermore, in fourteen of the twenty-four cases the lesion was most manifest at the superoposterior margin of the petrosa (fig. 3). While it is true that the lesion in the petrosa may extend into the apex, the pathologic changes at that site are usually not so marked as in the lateral portion of the pyramid. We found moderately severe inflammatory changes in eleven of the apexes sectioned, slight changes in four and relatively normal findings in five. In only three were the inflammatory changes in the apex more marked than those in the remainder of the pyramid (fig. 5). The duration of the infectious

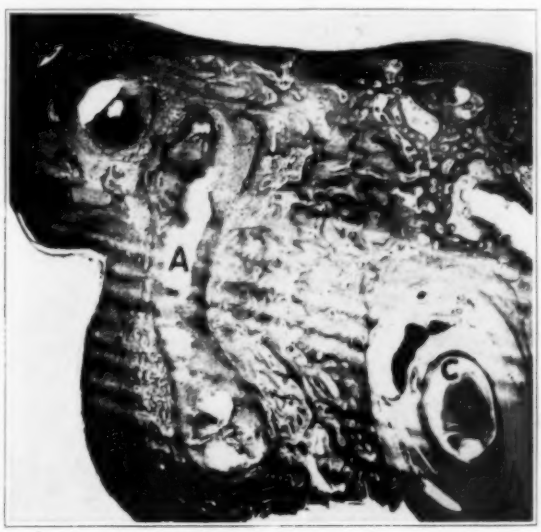

Fig. 5.—A section showing a large abscess (*A*) in the apex of the petrosa. *C* indicates the carotid artery.

process may be a factor in the extent of the involvement of the petrosa and apex. As we have previously demonstrated and as is well known, the suppurative process frequently erodes the bony cortex of the petrosa along the middle or posterior fossa at an appreciable distance from the apex and produces an extradural abscess (fig. 6). These changes may take place before any considerable degree of involvement of the apex has occurred.

In eleven of the twenty-four cases there was either a frank extradural abscess (fig. 7) or a communication between the suppurative process in the bone and the adjacent overlying dura. The process involved chiefly the dura of the middle fossa in seven cases and that of the posterior fossa in four cases. In a few of these there were

multiple perforations of the bony cortex of the pyramid in the middle or posterior fossa or in both (fig. 3). The inflammatory changes in the dura varied in extent; they remained localized in some cases and in others they extended to the apex.

Fig. 6.—A gross specimen of the superior aspect of the petrous pyramid showing erosion (*A*) of the bony cortex medial to the superior semicircular canal (*B*). The dura (*D*) has been reflected.

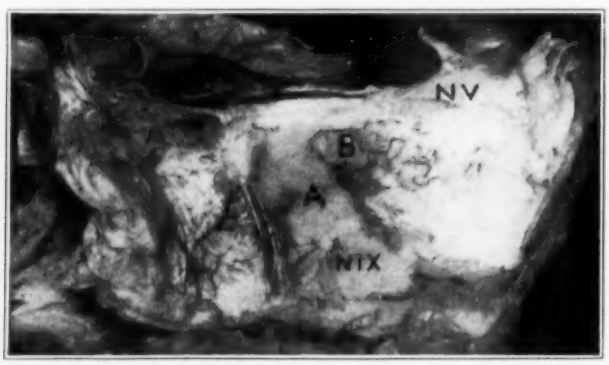

Fig. 7.—A gross specimen of the posterior aspect of the petrous pyramid showing a large extradural abscess (A) in the region of the internal auditory meatus (*B*). *NV* indicates the trigeminal nerve, and *NIX*, the glossopharyngeal nerve.

PATHOLOGIC CHANGES IN THE FIFTH, SIXTH, SEVENTH AND EIGHTH NERVES

In fifteen cases there was definite involvement of the gasserian ganglion. This was evidenced by swelling and by degenerative changes

of the ganglion cells. There was a large amount of inflammatory cellular exudate between the ganglion cells and the bundles of the fifth nerve and within the adjacent dura. The dura showed a variable amount of thickening. The inflammatory changes in the gasserian ganglion and the adjacent bundles of the fifth nerve could not always be correlated with the clinical symptoms. The pathologic changes in the ganglion and the fifth nerve were not always associated with the characteristic pain or the distribution of the latter. Thus, there were cases in which marked inflammatory changes existed within and about the ganglion and yet the deep-seated pain in the eye was lacking. At times the reverse condition was present.

Recently the deep-seated pain in the eye has been attributed to lesions in the superficial petrosal nerves and in the vidian nerves. The facts that these nerves are in closer proximity to the lesion in the petrous pyramid than the gasserian ganglion and that the course of these nerves for the most part is extradural were offered as reasons for this belief (Vail). Although a study of the vidian nerve could not be made from the histologic sections of the petrosa, the superficial petrosal nerves could be studied. In some cases there was engorgement of the vessels about the nerves with swelling of the nerve fibers. Others showed little if any change. On the whole, no definite conclusions could be drawn as to an etiologic relationship between these nerves and the presence of pain. Selective histologic studies of nerves, however, were not made.

Pathologic changes of the sixth nerve could not be demonstrated in every specimen sectioned. In five cases palsy of the external rectus muscle was present. In general, it may be stated that the paralysis of the sixth nerve could not always be accounted for by the pathologic findings. Cellular infiltration and thickening of the dura about the nerve were the most common findings. It is significant that in each instance the onset of the palsy followed a period of pain.

It is of interest to note that in eighteen of the twenty-four cases inflammatory changes within and about the geniculate ganglion were noted. These consisted of engorgement of the vessels about the ganglion, cellular and hemorrhagic infiltration between the ganglion cells and degenerative changes within the cells. Though these changes may be attributed in part to disease in the petrous pyramid, there is no doubt that in some cases they were secondary to terminal meningitis. These pathologic changes are not always associated with facial paralysis or paresis. In four cases facial paralysis was a terminal event.

In the course of the petrositis there may be associated labyrinthitis (fig. 6). The latter may be independent of the former or may be secondary to it. In the latter event the labyrinthine capsule is eroded by the inflammatory process and single or multiple fistulas are produced. In two of our cases such fistulas into the labyrinth secondary to suppura-

tion of the petrous pyramid were present. In two cases there were signs or symptoms which could be attributed to involvement of the labyrinth. In one there were vertigo, nausea and vomiting; in the other there was total deafness. In neither of these was labyrinthitis disclosed histologically. A deep subdural abscess in the region of the internal auditory meatus, pressing on the nerves, was considered as the possible causative agent. This condition, however, was not found on histologic examination.

Of the twenty-four patients thirteen had signs of intracranial complications on admission: Nine had signs of meningitis, and four of abscess of the brain.

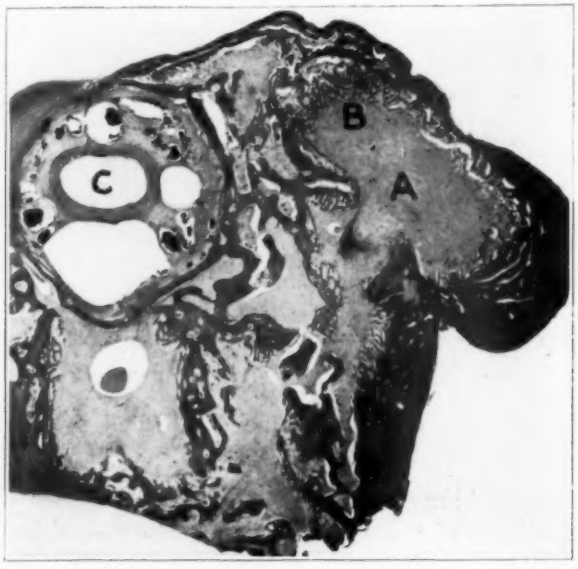

Fig. 8.—A section through the apex showing an abscess (*A*) in a state of healing by fibrosis and formation of new bone (*B*). *C* indicates the carotid artery.

Reparative processes in cases of suppuration of the petrous pyramid take place at an early stage of the disease. Granulation tissue, fibrous tissue with scarring and new bone formation can be demonstrated in the histologic sections (figs. 8 and 9). The new bone is formed not only from the periosteal lining but also by a process of budding from the old bone into the adjacent fibrous tissue. The osteoblastic activity is a dominant feature. This effort at repair not only takes place after resorption of bone has been completed but may go on concomitantly with it. It is of interest that the formation of new bone may occur at a considerable distance from the active inflammatory lesion. This holds true particularly for the periosteal type of new bone.

The dura undoubtedly plays a rôle in the walling off of the disease process in the bone and in the prevention of its spread to the intracranial contents. This is evidenced by marked reactive changes within the dura, namely, thickening, cellular infiltration, granulation and scar formation. As a result of scar formation within the bone the inflamed dura may be drawn through the defect in the cortex into the petrous pyramid and in this way wall off the disease process (fig. 10).

SYMPTOMATOLOGY

Pain.—In the consideration of the symptomatology of disease of the petrous pyramid, it is obvious from our material that there are no

Fig. 9.—A section of new bone formation (*A*) in the apex in the region of the dura and carotid artery (*C*). In this case the greatest expression of the disease was in the most lateral portion of the petrous pyramid (fig. 3).

symptoms which are invariably associated with this condition. The most significant symptom is pain. Furthermore, provided other etiologic factors have been excluded, the presence of pain is much more important than its localization. Thus we have found pain referred to the temple, the supra-orbital region, the eye, the teeth, the face and the ear. Rarely, pain from petrositis is referred to the posterior part of the skull. The pain may be intermittent, but more frequently it is continuous, with marked exacerbations. Pain from this condition may occur during the first week of otitis or may begin in from one to a number of weeks following a mastoidectomy. Generally speaking, after an adequate operation for suppurative mastoiditis, the later the onset of pain the

graver is its significance. Perhaps pain which comes on late is a manifestation of meningeal irritation or other intracranial complication secondary to insidious osteitis of the petrous pyramid. Rarely, sensory changes occur in the cornea or the face.

In our clinical cases the cessation of pain marked the beginning of recovery. In the pathologic material, on the other hand, pain persisted in every instance but one, in which suppuration of the petrous pyramid had perforated the cortex and involved the dura. We therefore have found little ground for the belief that the cessation of pain is a grave symptom and is indicative of an extension of the suppurative disease beyond the limits of the bone.

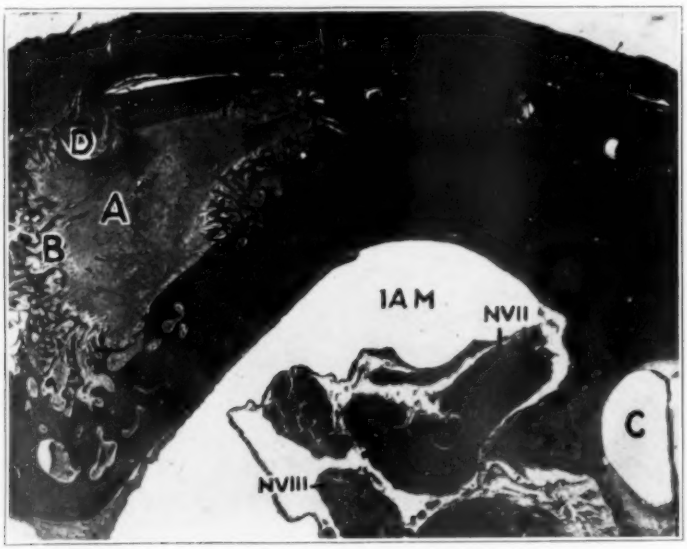

Fig. 10.—A section of an area of osteitis (*A*) at the superoposterior margin of the petrous pyramid, showing the process of healing. New bone formation (*B*) in dural invagination (*D*) into a perforation of the cortex can be seen. *C* indicates the cochlea, *IAM*, the internal auditory meatus; *NVII*, the facial nerve, and *NVIII*, the eighth nerve.

Otorrhea.—The generally accepted belief that serious disease in the petrous pyramid is always associated with persistent or recurring discharge from the tympanum is also erroneous. In the presence of pain a scant discharge is of much more grave import than a profuse discharge. Heretofore insufficient stress has been laid on the type of case in which there is pain following acute otitis and an operation for mastoiditis and in which the middle ear is dry and the process in it resolved and the mastoidectomy wound is healed. In our experience this condition is extremely serious.

In an earlier communication we demonstrated histologically that in cases of osteitis of the pyramid inflammation of the superficial structures, i. e., middle ear or antrum, may resolve and heal, yet virulent infection with progressive destruction may occur in the depths of the petrosa. We have encountered instances also in which, following acute suppurative otitis and symptoms of mastoiditis, operation disclosed little or no gross disease in the mastoid. Not infrequently in these cases the middle ear undergoes rapid resolution and the mastoidectomy wound heals. The hearing may be excellent. The persistence of severe pain, with or without fever, demands immediate surgical intervention. In this type of case we have seen, both during operation and histologically, the most extensive destruction in the pyramid. Occasionally too, palsy of the external rectus muscle supervenes during the persistent pain and must be considered a focal sign.

Osteitis of the pyramid may occur as a complication of acute suppurative otitis media or acute suppurative mastoiditis. Under such circumstances a short time following the operation on the mastoid a profuse discharge begins to issue from the middle ear, the mastoidectomy wound or both. It is in this type of case, in which the bone focus obviously is draining, that we have used conservative measures. We have shown that the discharge contains the products of disintegration of bone, at times as much as 37 mg. of calcium per hundred cubic centimeters (Friesner and Rosen[59]). We have observed instances in which profuse discharge persisted for four or even eight weeks. We have had roentgenographic evidence of changes in the petrous pyramid in the presence of a completely exenterated mastoid, yet the absence of high fever, the gradual diminution of pain and the lack of evidence that an intracranial extension was imminent led us to persist in our conservative course. In many of the cases in this group the patient recovered spontaneously. Furthermore, it is most important to note that when recovery took place, even after eight weeks of profuse discharge, there were a healed mastoidectomy wound, a normal middle ear and normal hearing.

Involvement of the Sixth Nerve.—As in the case of pain, time is an important factor in the significance we attach to the onset of palsy of the external rectus muscle. With our knowledge that extensive destruction in the petrous pyramid may go on insidiously, the late development of paralysis of the sixth nerve or paresis associated with pain is of much greater significance than palsy of the external rectus muscle which occurs a few days after the beginning of acute otitis or acute mastoiditis.

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59. Friesner, I., and Rosen, S.: Calcium Content of Pus, J. A. M. A. **88**:1231 (April 16) 1927.

We have already referred to the fact that when palsy of the external rectus muscle supervenes during the persistent pain after a mastoidectomy wound is healed and the middle ear is dry and the process in it resolved such evidence must be considered a focal sign of disease of the pyramid, provided there is no other evidence of intracranial complication.

On the other hand, the mere presence or absence of paralysis of the sixth nerve is not in itself of sufficient moment to sway our attitude toward conservatism or intervention provided the other factors for making a decision are present. In other words, the indications to interfere surgically may be quite clear despite the absence of paralysis of the sixth nerve, and, conversely, the basis for conservatism is not upset by the development of such a lesion alone.

Fever.—We have not found that fever is a characteristic symptom in cases of suppuration of the petrous pyramid. Extensive disease may be present without fever. In the vast majority of our cases studied clinically, the temperature varied between 99 and 100 F. The persistence of elevated temperature following surgical intervention in a case of mastoiditis, however, is suggestive of an undrained focus in the bone. We believe that this applies particularly to adults, since frequently in children the diurnal curve mentioned earlier may be normal. Rarely the temperature is somewhat similar to that which occurs in the course of a general invasion. We have observed a case of petrositis in which there was repeated elevation of temperature to 104 F. without meningeal signs or bacteremia. Recovery was prompt after intervention.

Involvement of the Seventh Nerve.—Despite the fact that our pathologic material shows frequent involvement of the seventh nerve, particularly in the region of the ganglion, we have had little clinical experience with facial paresis or paralysis in this condition. In the presence of other symptoms of petrositis the development of paralysis of the seventh nerve may be the evidence of extensive disease in the petrosa. On the other hand, we have had under our observation a patient who because of pain, an unhealed mastoidectomy wound, slight fever, otorrhea and facial paralysis was about to be subjected to an operation on the petrous pyramid. He was completely relieved by the exenteration of a large zygoma and the peribulbar cells lying between the sinus and the jugular bulb.

Involvement of the Eighth Nerve.—In four of our cases studied histologically, there was evidence of suppuration in the labyrinth. In three of these there was clinical evidence of damage to the eighth nerve. The fourth was in a child in whom there were no characteristic symptoms. It is remarkable how frequently in the cases studied histologically extensive disease is encountered in the pyramid without

involvement of the labyrinth. Symptoms of damage to the eighth nerve may occur, however, not only from invasion of the internal ear itself but also from disease in the petrosa which has extended to and involved the bony walls of the internal auditory canal. Vertigo was not a common symptom in our acute cases. Obviously with diplopia or blurring of objects due to paresis of the external rectus muscle, vertigo may be present.

Involvement of the Ninth and Tenth Nerves.—Mention must be made, too, of the rare symptoms, hoarseness and difficulty in deglutition, which accompany lesions of the ninth and tenth nerves. When suppuration is present in the hypotympanic group of cells it may cause peribulbar inflammation or abscess with involvement of the ninth and tenth nerves. In two of our cases studied histologically pathologic lesions were noted in the peribulbar region with involvement of the ninth and tenth nerves, but there were no clinical symptoms referable to these nerves (fig. 7).

REPORT OF CASES

In the period from 1929 to 1934, during which we accumulated our information concerning the pathologic changes in suppurative disease of the petrous pyramid and, more specifically, the localization, extent and pathways of such infections, a number of cases of a condition diagnosed clinically as petrositis came under our observation. In each of these cases recovery was spontaneous. We believe that by correlating our clinical with our histopathologic material we have acquired not only a more thorough understanding of the progress of the disease but also a clearer conception of some of the conditions which require surgical intervention.

CASE 1.—E. S., aged 7 years, was admitted to the hospital on Jan. 3, 1933, and discharged on January 21. The child was readmitted on February 16 and was discharged on March 11. On January 1 a left myringotomy was performed, at which time pus was obtained. On January 8 a simple mastoidectomy was performed. Discrete abscesses were found throughout the mastoid, and pus was found in the tip. On January 21 the patient, having made an uneventful postoperative recovery, was discharged for further observation. On February 9 there was complaint of frontal headache and pain behind the left eye, and the patient vomited. A profuse discharge saturated the dressing. On February 16 the patient was readmitted to the Mount Sinai Hospital with preauricular edema of the left side. Exploration of the mastoid yielded negative findings. The postauricular discharge was profuse. The middle ear was dry, and hearing was good. By February 21 the discharge was diminishing, the pain behind the eye was gone, and the temperature was 100 F. On February 23 there was profuse discharge from the mastoidectomy wound. On March 5 the wound was clean, and there was very little discharge. Hearing was normal.

The first pain occurred thirty-nine days after myringotomy and lasted for ten days. This case demonstrates spontaneous discharge from the petrous pyramid with complete recovery, normal hearing and a dry middle ear.

Case 2.—H. F., aged 7 years, was admitted to the hospital on April 16, 1931, and was discharged on June 10. On March 19 there was spontaneous discharge from the right middle ear. On April 16 a simple mastoidectomy was performed. The mastoid process was pneumatic, and there was widespread suppuration with softening of the bone in the solid angle. The temperature was 102 F. On April 24 there was a moderate amount of discharge from the wound and from the middle ear. The temperature ranged from 100 to 101 F. On April 28 there was pain in the right eye and a hemicranial headache on the right. On May 2 the middle ear was dry, and there was a slight amount of postauricular discharge. On May 4 there was a profuse discharge from the wound and from the middle ear. The ocular pain was gone, but paresis of the sixth nerve was present. On May 12 the middle ear was almost dry; the postauricular discharge was still profuse. On May 31 the middle ear was dry, the postauricular discharge was almost gone, and the paresis of the sixth nerve was much improved. On June 7 the patient was ambulatory; the sixth nerve was almost normal, and there were no other symptoms.

The first pain occurred forty days after spontaneous perforation and lasted for six days. This case demonstrates the typical history, symptoms, profuse discharge and involvement of the sixth nerve frequently associated with suppuration of the petrous pyramid. There was spontaneous drainage from the petrous pyramid. The patient made an uneventful recovery after a complete simple mastoidectomy, and now has a dry tympanum and normal hearing.

Case 3.—P. S., aged 12 years, was admitted to the hospital on July 2, 1931, and was discharged on August 8. On June 17 a myringotomy was performed on the left side, at which time pus was obtained. On July 2 a simple mastoidectomy revealed the mastoid to be large and pneumatic and the seat of extensive purulent necrosis. The postoperative course was normal. The middle ear became almost dry. On July 9 the patient complained of headache in the frontal area on the left side and pain in the left eye. On July 30 the pain in the eye was diminishing. There was a profuse discharge from the middle ear and from the postauricular wound. From July 30 to September 12 the discharge diminished and finally ceased completely. The middle ear was dry, and hearing was normal.

The onset of ocular pain occurred twenty-two days after myringotomy. Pain in the eye lasted for thirty days.

In this case of suppuration of the petrous pyramid there was a spontaneous discharge. The discharge was extremely profuse, requiring daily dressings. Recovery was complete, with a dry middle ear and normal hearing.

Case 4.—E. W., aged 55, was admitted to the hospital on April 4, 1932, and was discharged on May 29. On March 20 a myringotomy was performed on the left side, at which time pus was obtained. On April 4 there were pain in the left eye, tenderness over the mastoid, a profuse discharge and headache on the left side. A simple mastoidectomy on the left side revealed no disease process but a large pneumatic mastoid. From April 4 to May 5 there was profuse discharge from the middle ear and from the postauricular wound with excruciating pain in the eye. On April 28 paralysis of the left sixth nerve appeared. By May 20 the sixth nerve was almost well. After May 5 there was less pain in the eye and less discharge from the middle ear. By May 29 the ear was dry and hearing was normal and the temperature varied from 99 to 99.5 F.

The onset of pain occurred fifteen days after myringotomy and lasted for fifty-five days. The profuse discharge from the middle ear and from the postauricular wound indicated that the focus in the pyramid was draining spontaneously. There

was no sign of meningeal involvement. The clinical picture indicated that the bony pyramidal lesion had not extended to or involved the intracranial structures. The patient made a complete recovery with a dry middle ear and normal hearing. No operation on the pyramid was performed because the drainage seemed adequate and no alarming signs presented themselves.

CASE 5.—M. C., aged 20, was admitted to the hospital on Feb. 25, 1931, and was discharged on March 23. On February 7 a myringotomy was performed on the left side, at which time pus was obtained. On February 12 the patient complained of pain in the left temple, the eye and the occiput. By February 25 there was a scant discharge from the left ear, hearing was reduced to recognition of a moderately loud whisper, the temperature was 100 F., there was complete paralysis of the sixth nerve and pain continued in the left temple, the eye and the occiput. On February 28 a roentgen study showed cloudiness of the mastoid and the petrous pyramid. Simple mastoidectomy was performed. There was no pus and no breaking down of the bone. There was thin yellow serum in the intact cells. On March 3 there was still pain in the eye and the temple with an increasing discharge from the tympanum. The sixth nerve was completely paralyzed. A soft whisper could be heard. By March 6 the pain and headache were diminishing, but there was profuse discharge from the middle ear. By March 11 the sixth nerve was improving and the ear was almost dry. On March 16 the patient was free from symptoms. The sixth nerve was improving. On March 21 the sixth nerve was almost normal, and on March 23 the patient was discharged with a dry ear and normal hearing.

The first pain occurred five days after myringotomy and lasted for thirty-six days. This case demonstrates suppuration of the petrous pyramid without mastoiditis. There was roentgenographic evidence of inflammatory change in the petrosa with spontaneous discharge from the pyramid through the tympanum, with recovery.

CASE 6.—M. P., aged 35, was admitted to the hospital on Aug. 2, 1934, and was discharged on September 28. On June 15 myringotomy was performed on the right side, at which time pus containing type III pneumococcus was obtained. On July 25 the patient complained of headache on the right side and mildly oppressive pain behind the right eye. On August 3 simple mastoidectomy disclosed an extremely large, pneumatic mastoid which was the seat of extensive suppurative disease with a perisinuous abscess. On August 9 severe pain appeared back of the right eye. The temperature was 104.6 F. A blood culture gave negative results. There was a very profuse discharge from the ear and the wound. On August 11 to 15 there was no pain or symptoms, although there was still profuse discharge from the ear and from the wound. On August 19 there was severe frontoparietal pain behind the right eye. The ocular pain continued moderately but the discharge continued to be profuse until September 4, when the pain in the eye was gone. There was slight weakness of the sixth nerve. On September 10 there was a profuse discharge from the middle ear, which showed 36 mg. of calcium per hundred cubic centimeters. On September 17 there was very little discharge from the ear, and the sixth nerve was improving. On September 26 the middle ear and the postauricular wound were almost dry. Hearing was normal.

Pain first appeared forty days after myringotomy. Severe pain continued for six days after mastoidectomy and lasted for thirty-two days with varying intensity. This case of suppuration of the petrous pyramid also demonstrates recovery following spontaneous drainage from the postauricular wound and the tympanum.

CASE 7.—J. L., aged 26, was admitted to the hospital on Sept. 14, 1933, and was discharged on September 26. On July 30 spontaneous perforation of the right drum occurred. On August 9 a simple mastoidectomy was performed in another hospital. The patient was well until September 9, when severe pain appeared in the right eye and the right side of the head. On September 10 there was revision of the mastoid. On September 14 the patient was admitted to the Mount Sinai Hospital with headache on the right side, pain in the right eye, some nystagmus directed to the left, a temperature of 104 F. and a bilateral Kernig sign. There was profuse discharge from the middle ear and from the mastoidectomy wound. Roentgen study showed cloudiness of the right petrosa. On September 15 the pain in the eye and the headaches were less, and by September 17 they were gone. The temperature gradually subsided to 101.8 F. The nystagmus was gone. On September 22 the discharge from the ear was profuse. The temperature was less than 100 F. for several days. On September 25 there was a slight discharge from the ear and the wound.

The onset of pain and headache occurred forty-one days after perforation, and the duration was eight days. It is interesting to note the spontaneous recovery in this case. If a patient with this history and these physical signs were admitted to the hospital today, we should feel that immediate exploration of the pyramid should be carried out.

TREATMENT

The early literature and our own clinical experience as well as the more recently reported experience of others lend support to our belief that suppuration confined within the petrous pyramid has a marked tendency toward spontaneous cure. (Voss,[6] Baldenweck,[40] Ruttin,[60] Sears,[3] Perkins,[2] Neumann.[41]) This fact is based obviously on such widespread clinical experience that it is patent that the presence of suppuration of the petrous pyramid is not in itself a valid indication for immediate operation on the structure.

As one reviews the treatment of suppuration of the petrous pyramid in the earlier days one cannot but receive the impression that the main efforts of the pioneer otologists were directed not toward coping with infection confined within the pyramid itself but rather toward instituting drainage when the purulent focus had given evidence of extending beyond the limits of the bone.

Two years prior to the original publication of Gradenigo, Streit[61] devised a method for draining foci of suppuration in the apex of the petrous pyramid. After temporal decompression and removal of the tegmen and zygoma Streit lifted the temporal lobe from the base of the skull. He separated the dura from the anterior surface of the petrous pyramid as far as the impressio trigemini, thus affording a direct path

60. Ruttin, E.: Zur Klinik und Operation der Pyramidenspitzeneiterung und des periapikalen Extraduralabscesses, Acta oto-laryng. **19**:55, 1933.

61. Streit, H.: Ueber die Freilegung der vorderen Flache zwecks Aufsuchung von tief liegenden Krankheitsprocessen des Felsenbeines, Verhandl. d. deutsche otol. Gesellsch. **11**:91, 1902.

to the apex. Unterberger [62] recently successfully utilized the Streit procedure in a patient with petrositis and an extradural abscess. He suggested that lumbar puncture be done in these cases to decrease the intracranial pressure and thus facilitate the performance of the operation. Smith [63] and Goris [64] separately described methods for obtaining an exposure sufficient to drain extradural accumulations at the apex of the petrous pyramid. Broeckaert [65] in 1915 described an instance of involvement of the fifth and sixth nerves in which at operation no disease was found in the mastoid. He then lifted a long strip of bone above the base of the zygoma, laying bare the floor of the middle fossa and affording the same potentialities for reaching the apex of the pyramid as the procedure of Streit,[61] Smith,[63] Goris,[64] Krause [66] and others. In our opinion, these procedures, though similar to, are not as advantageous as, that of Eagleton.[67] Decompression of the middle fossa alone is inadequate, first, because disease may be on the posterior petrosal surface, and, second, because what Eagleton has termed the posterior buttress, if left in place, limits the lifting of the temporal lobe from the floor of the middle fossa.

Lillie and Williams [68] and others have reported cases of suppuration of the petrous pyramid in which the patient recovered following complete simple mastoidectomy. They believed that when there are well developed air cells in the petrosa their presence will have disturbed the usual distance relationships between the walls of the petrous pyramid and the labyrinth and it will be easy therefore in these cases to follow the infected cells into the depths of the pyramid. Ballenger [69] accepted Lillie's suggestion of entering the petrous bone through the mastoid proper and added that he thought it less dangerous than the procedure

62. Unterberger: Anatomisches zur streitschen Pyramidenspitzenfreilegung bei Gradenigoschen Symptomenkomplex nebst Mitteilung eines so operierten Falles, Ztschr. f. Hals-, Nasen- u. Ohrenh. **34**:293, 1933.

63. Smith, A. E.: A Contribution to the Anatomy and Surgery of the Temporal Bone, Am. J. M. Sc. **125**:563 (April) 1903.

64. Goris: Un cas de chirurgie cérébrale pour complication d'otite moyenne chronique; guérison, Ann. de mal. de l'oreille, du larynx **29**:64, 1903.

65. Broeckaert, J.: Intervention par la voie supra-auriculaire en cas de paralysie otique du moteur oculaire externe associée à la neuralgie du trijumeau, Rev. de laryng. **2**:209, 1914-1915.

66. Krause, F.: Zur Freilegung des Kleinhirns und der hinteren Felsenbeinfläche, Deutsche med. Wchnschr. **28**:367 (Dec. 18) 1902.

67. Eagleton, W. P.: Unlocking of Petrous Pyramid for Localized Bulbar (Pontile) Meningitis Secondary to Suppuration of the Petrous Apex, Arch. Otolaryng. **13**:386 (March) 1931.

68. Lillie, H. I., and Williams, H. L.: Suppuration of the Petrous Pyramid, Arch. Otolaryng. **15**:692 (May) 1932.

69. Ballenger, H.: Petrositis, Arch. Otolaryng. **17**:728 (May) 1933.

advocated by Kopetsky and Almour. Seydell [70] after consideration of all the factors in the handling of petrositis stated:

> Where extensive pneumatization of the mastoid and petrous pyramid exists, drainage of the infected air cells and the marrow of the pyramid may be accomplished without impairing the normal functions of the middle ear by radical mastoidectomy. The petrous tip may be reached through either of the groups of mastoid cells which lie anterior or posterior to the capsule of the labyrinth. The technique employed does not require special apparatus or instruments. It is much simpler and requires less time than the operation proposed by Eagleton or by Kopetsky and Almour.

Although Seydell included the Eagleton procedure in his comparison, it is obvious from the description of his method of surgical intervention that he really performed the operation described by Eagleton. Of interest, however, is the fact that Seydell decompressed the posterior fossa and first searched for disease in this region. Probably his experience led him to suspect the presence of an abscess in this situation rather than elsewhere in the pyramid.

Observers have frequently discovered purulent foci about the internal auditory meatus or medial to the labyrinth and have devised methods for draining these areas. When Oppikofer [71] suspected the presence of an extradural abscess in the region of the internal auditory meatus with impending meningitis he favored the translabyrinthine route. Holmgren,[72] Jungert [73] and Uffenorde [8] were in accord with these views. Frenckner [74] devised a procedure, which Galtung [75] recently employed successfully, to drain the petrous pyramid through the arch of the superior semicircular canal. Frenckner [74] and Knick [76] have expressed the opinion that a knowledge of the condition of the spinal fluid is often of value in conjunction with the clinical picture in determining when to intervene. Kopetsky and Almour in 1932 reported the results of their operative procedure in which a drill is used. The petrous pyramid between the carotid canal and the cochlea is entered

70. Seydell, E. M.: Suppuration of the Petrous Pyramid, Tr. Am. Laryng., Rhin. & Otol. Soc., 1933, p. 561.

71. Oppikofer, E.: Ueber die extraduralen Abscesse der Felsenbeinspitze in den Gradenigoschen Symptomkomplex, Ztschr. f. Hals-, Nasen- u. Ohrenh. **21**:454, 1928.

72. Holmgren, G.: A Case of Gradenigo Syndrome, Acta oto-laryng. **4**:491, 1922.

73. Jungert, Y.: Einiges über das Syndroma Gradenigo und die Erfahrungen darüber an der Klinik auf Sabbatsberg, Acta oto-laryng. **16**:394, 1931.

74. Frenckner, P.: Some Remarks on the Treatment of Apicitis (Petrositis) With or Without the Gradenigo Syndrome, Acta oto-laryng. **17**:97, 1932.

75. Galtung, A.: Some Remarks on the Treatment of Apicitis (Petrositis) in General and on Frenckner's Operation in Particular, Acta oto-laryng. **18**:487, 1933.

76. Knick, A.: Die Abduzenslähmung bei Otitis media, Ztschr. f. Hals-, Nasen- u. Ohrenh. **3**:136, 1922.

after a radical mastoidectomy is performed. Sunde [39] in 1934 reported an interesting case of suppuration of the petrous pyramid with so-called classic symptoms in which he performed a radical mastoidectomy, expecting to find a carious focus or a lead in the peritubal region. Not finding any, he investigated further in the region of Trautman's triangle and uncovered a group of cells leading underneath the labyrinth. With a fine curet, these cells were opened and an abscess was evacuated. Following this procedure the meningeal signs disappeared, and the patient made a complete recovery. Johnson [77] in 1934 reported an almost analogous experience, in which he discovered the greatest expression of the disease in the posterior portion of the pyramid in the region of the internal auditory meatus. Serial roentgenograms in Johnson's case indicated definite destructionn in the pyramid. Hagens [78] reported three cases of petrositis with otitic intracranial complications in which the most marked manifestations of the infectious process were in the posterior portion of the pyramid. Uffenorde [31] and Oppikofer [71] were in accord with Brock [79] in the observation that in most cases of suppuration of the petrous pyramid the extradural abscess is located above the internal auditory canal and not at the apex. They have expressed the belief that this can be explained by the fact that there is most often perilabyrinthine cell structure in this portion of the pyramid. Richards [80] reported five chronic suppurative cases in all of which recovery followed exenteration of the pyramid. This author was impressed by what he termed the outstanding pathologic feature in these cases, namely, a collection of pus at the posterior petrosal surface, either at the internal auditory meatus or just above it.

We have learned from our pathologic material that in the vast majority of cases suppuration of the pyramid extended from the middle ear and mastoid antrum through the superior and posterior group of perilabyrinthine cells. Second, in only a few was the major expression of disease at the apex of the pyramid. As has been stated before, in all the cases observed clinically the patients have recovered with normal ears and normal hearing. Of all the types of surgical intervention described in the literature we have utilized a procedure described by Eagleton [66] and have added few modifications. In most instances this procedure gives adequate exposure, particularly of the region in which

77. Johnson, C. I.: Petrositis, Arch. Otolaryng. **17**:724 (May) 1933.

78. Hagens, E. W.: Acute Suppuration of the Temporal Bone, Arch. Otolaryng. **10**:21 (July) 1929.

79. Brock, W.: Demonstration mikroskopischer Präparate eines Falles mit Empyem im Dache des innern Gehörgangs, Ztschr. f. Hals-, Nasen- u. Kehlkopfh. **6**:380, 1923.

80. Richards, J. D.: The Petrous Pyramid: Its Surgical Anatomy and Technique of Operation for Its Removal, Am. J. Surg. **2**:11, 1927.

disease is most apt to be found; the surgical measures can be performed under direct vision, and the essential parts of the ear are conserved. We have not found it necessary to perform radical mastoidectomy.

We have found that withdrawal of the cerebrospinal fluid adds considerably to the facility with which one can retract the dura in contact with the pyramid and explore the underlying bone. In the literature (Unterberger) lumbar puncture has been suggested for this purpose. However, in one instance in which there was some doubt as to the presence of a cerebellar abscess and lumbar puncture was inadvisable Kaplan [81] suggested drainage of the ventricular system by emptying the lateral ventricle opposite the pyramid about to be explored. We found this so efficacious that we give it serious consideration in all cases, especially in those in which the advisability of lumbar puncture is questioned. Avertin anesthesia should be used because it does not increase intracranial anesthesia as markedly as inhalation anesthesia does.

As a preliminary to the decompression a complete mastoidectomy is done or, if the mastoid has been operated on, a thorough search is made for leads into the pyramid, with particular attention to the region of the solid angle through which most of the infections of the pyramid extend. An equally careful exploration of the peribulbar cells and the cells in the zygoma is carried out. Not infrequently by following these leads an abscess in the first portion of the pyramid is evacuated with complete cessation of symptoms as a sequel. In this exploration it is essential to expose carefully both the superior and the posterior canal. Thus far we have not found it necessary to perform radical mastoidectomy in the acute cases.

We extend the incision for the decompression upward about 3 inches (7.6 cm.) from the upper angle of the mastoidectomy wound, which has been carried above the auricle. A second incision is made about 2 inches (5 cm.) directly backward from the middle of the mastoidectomy wound toward the external occipital protuberance. The soft parts are then retracted. We have used the Albee drill but have not found it necessary, particularly in children. The decompression is begun over the squama. This is removed with a rongeur, as is the bone overlying the sinus and cerebellar dura immediately behind the cerebellar dura and as far forward toward the posterior semicircular canal as possible. In separating the dura from the bone we use ordinary brain retractors. Care must be exercised to remove the bone completely in the angle between the middle and the posterior fossa. The floor of the middle fossa lying over the antrum and aditus should be removed to the superior semicircular canal. The posterior part of the zygomatic root should

81. Kaplan, A.: Personal communication to the authors.

also be bitten away. When completed the removal should expose the dura in an area approximately 4 inches in diameter. With this exposure, particularly after the ventricular system has been emptied of cerebrospinal fluid, it is comparatively simple by retracting the dura and using a Cameron light and suction to inspect almost the entire superior surface of the petrous pyramid as well as a considerable part of the posterior surface. If disease is encountered in the exposed bone, the area is curetted and opened with an ordinary mastoid curet. On the superior surface great care must be exercised to curet gently in a direction from before backward, away from the carotid artery. After curetting the abscess cavity we have placed rubber tissue between the bone and the dura. In two instances it was left in situ for seven weeks. If no perforation through the bone is encountered, the bone is tested by pressure with a Spratt curet. If no lead is found, rubber tissue or a drain is placed between the dura of the middle fossa and the surface of the pyramid. Under ordinary conditions we feel that to enter unopened tracts by chiseling through the petrous cortex is inadvisable, the exception being in case of impending or established meningitis. We realize that the part of the posterior pyramidal surface between the internal auditory meatus and the apex cannot be exposed with this technic, and, furthermore, it is impossible with any procedure to drain adequately all foci in the pyramid. Nevertheless, we believe that the operation embodies basic surgical principles, namely, a visible operative field and maximum exposure of the areas in which disease is most frequently found, with conservation of important structures.

INDICATIONS

In considering the indications for operation on the pyramid we have attempted to base our conclusions on our pathologic, clinical and surgical experience. The indications in some instances are, according to our views, clearcut. In other situations each case must be judged by itself, with the application of all possible criteria, including a study of the cell content of the cerebrospinal fluid. Here, too, due consideration must be given to the time relationship between the onset of the otitis and the development of symptoms indicative of petrosal disease. As a general rule the later the onset of symptoms indicative of disease in the pyramid the graver their import.

The cases in which indications are present for exploration of the pyramid may be divided into two groups:

1. *Cases in Which No Mastoidectomy Has Been Performed.—A.* In cases in which the ear has been discharging for several weeks and in which the pain has persisted or has become increasingly severe, particularly when to the original pain in the eye, in the teeth or in the

ear there is added severe frontal headache, exploration of the pyramid should immediately follow a mastoidectomy if the findings in the mastoid are inadequate to explain the pain.

B. In cases in which the ear has been discharging for several weeks and the pain has not been relieved, if meningeal signs (meningeal sympathica) develop and the findings in the mastoid at operation are inadequate to explain the intracranial extension, exploration of the pyramid should be carried out immediately following the mastoidectomy. We realize, of course, that it is extremely difficult to paraphrase accurately the term "adequate findings to explain pain." In the final analysis, the personal interpretation of the surgeon is paramount. It might be timely, however, to reiterate that we have seen headache, pain in the eye, fever and persistent otorrhea from an undrained zygomatic abscess, involvement of the fifth and sixth nerves from an epidural abscess over the mastoid tegment, meningeal symptoms from a perisinuous and epidural abscess or sinus thrombosis. These are some of the findings in the mastoid that we consider adequate to explain pain. Of course, a badly and extensively diseased mastoid is another. Shambaugh [82] reported temporal headache and paralysis of the external rectus muscle caused by a small epidural abscess in the root of the zygoma.

2. *Cases in Which Mastoidectomy Has Been Performed.—A.* In some of the cases of acute otitis media with involvement of bone the major expression of the inflammation is in the pyramid rather than in the mastoid. Not infrequently in such a case, because of continued pain, profuse otorrhea, fever and tenderness the mastoid is operated on and discloses little or no pathologic change. The process in the middle ear may resolve rapidly and the mastoidectomy wound heal promptly. As we have already stated, the most virulent and most serious cases of osteitis of the petrosa are those in which the middle ear is dry and the mastoidectomy wound is almost or quite healed. In these, if severe pain persists or begins late, and particularly if focal signs (involvement of the sixth, seventh or eighth nerve) develop, operation is imperative. *B.* In our clinical experience by far the largest group of cases is of those in which following mastoidectomy disease in the pyramid manifests itself by pain and by the development of increasing discharge from the ear, from the mastoid or from both. As far as indications for operation are concerned, this group offers the most difficult problem. In this type of case all diagnostic criteria should be used. There can be no question that in many such cases the patient recovers spontaneously. Yet if at any time in the judgment of the surgeon an intracranial extension is imminent the pyramid should be explored.

82. Shambaugh, G.: Report of a Case, Tr. Am. Otol. Soc. **20**:262, 1930.

REGENERATION OF NASAL MUCOSA

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The diverse and frequently extensive manipulations of the nasal mucous membranes involved in surgical procedure on the nose and paranasal sinuses have generally been initiated and governed by the final results obtained. Most of the literature on experimentation on animals also has been devoted to this end. Such information would be enhanced and the rationale of some methods would be better evaluated if the primary reactions of the tissues to injury and the sequence of changes under different conditions were known. It has been the purpose of this study to supply at least some of that information. It might be assumed by the pathologist and the clinician familiar with regenerative processes in other parts of the body that these data are already available, but a review of the literature on the nose and trachea reveals that information of this sort is lacking for the pseudostratified epithelium characteristic of these regions.

Knowlton and McGregor [1] experimentally removed the lining of the antrums of a dog. Epithelial regeneration was well established within one month and appeared complete at the end of three months. When again observed after five months the subepithelial glands had regenerated, and the membrane appeared normal. Coates and Ersner [2] removed the entire mucosa from the frontal sinuses of a dog. They reopened one sinus after two months and ten days and found a completely regenerated membrane containing goblet cells and glands. The mucosa was again removed, and when observed seven months later the sinus was lined by a membrane normal in appearance except for signs of inflammation.

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1. Knowlton, C. D., and McGregor, G. W.: How and When the Membrane of the Maxillary Sinus Regenerates: An Experimental Study in the Dog, Arch. Otolaryng. **8**:647 (Dec.) 1928.

2. Coates, G. M., and Ersner, M. S.: Regeneration of the Mucous Membrane of the Frontal Sinus After Its Surgical Removal (in the Dog), Arch. Otolaryng. **12**:642 (Nov.) 1930.

Hilding [3] excised strips of mucosa from frontal sinuses of dogs and observed the formation of ridged scars. Openings made in septums between sinuses were closed by scar tissue if bare strips of bone encircled the opening but remained patent if the mucosa of the two connected sinuses was placed in apposition. In a later paper Hilding [4] reported obliteration of the sinus by scar tissue after complete removal of the mucosa. In a few instances the cavity was partially reformed, with or without regeneration of the epithelium, and in other cases mucin-filled cysts were seen in the scar tissue, evidently originating from small portions of retained epithelium.

These observations on the regeneration of mucosa in the sinuses of dogs have been confirmed and extended by the study of specimens obtained at autopsy or for biopsy after operations on the sinuses of human subjects. The formation of a lining of granulation tissue with beginning invasion of epithelium from the nasal cavity was observed by Tonndorf [5] in a man who died four weeks after a Caldwell-Luc operation. The pseudostratified ciliated epithelium was preceded by an area of flat nonciliated cells. Semenov and Kistner [6] reported regeneration of the mucosa of the antrum following the removal of 1 sq. cm. of mucosa. After four months, scar tissue covered with pseudostratified ciliated epithelium repaired the injury. When larger areas were removed, epithelium and sometimes glandular tissue regenerated, but they were not normal. Kistner [7] reported observations on membrane removed from ethmoid, sphenoid, frontal and maxillary sinuses previously operated on. Granulation tissue formed first and became organized into scar tissue, which was covered by epithelium similar to that of the region from which it originated.

Gorham and Bacher [8] obtained tissue for biopsy from regenerating antral mucosa after an operation in which the original mucosa was

3. Hilding, A.: Experimental Surgery of Nose and Sinuses: II. Gross Results Following Removal of the Intersinus Septum and of Strips of Mucous Membrane from the Frontal Sinus of the Dog, Arch. Otolaryng. **17**:321 (March) 1933.

4. Hilding, A.: Experimental Surgery of the Nose and Sinuses: III. Results Following Partial and Complete Removal of the Lining Mucous Membrane from the Frontal Sinus of the Dog, Arch. Otolaryng. **17**:760 (June) 1933.

5. Tonndorf, W.: Beitrag zur Ausheilung der nach Luc-Caldwell operierten Kieferhöhle, Ztschr. f. Hals-, Nasen- u. Ohrenh. **22**:54 (June 16) 1928.

6. Semenov, H., and Kistner, F. B.: Repair in the Paranasal Sinuses of Man Following Removal of the Mucous Membrane Lining, Proc. Soc. Exper. Biol. & Med. **27**:322 (Jan.) 1930.

7. Kistner, F. B.: Pathology of Sinusitis, Ann. Otol., Rhin. & Laryng. **38**: 977, 1929; Histopathology and Bacteriology of Sinusitis with Comments on Postoperative Repair, Arch. Otolaryng. **13**:225 (Feb.) 1931.

8. Gorham, C. N., and Bacher, J. A.: Regeneration of the Human Maxillary Antral Lining, Arch. Otolaryng. **11**:763 (June) 1930.

entirely removed. Complete regeneration of the mucosa, with ciliated and goblet cells and glands, took place within a period of from three to five months. The membrane first appeared as a mass of red cells and fibrin, which became organized and was invaded by capillaries and connective tissue at the end of three weeks. After four weeks this tissue was replaced by embryonic connective tissue, with an epithelium of normal type preceded by a flattened layer of cells. At autopsy McGregor [9] found regeneration to have occurred in several cases in which surgical intervention for the removal of infected sinus membranes had been carried out previously. Stratified squamous epithelium, which McGregor believed was produced by the transplantation of squamous cells from the nasal vestibule, was sometimes seen. Wright [10] discovered that mucous membrane will regenerate if the diseased condition is cured.

Some workers have reported from clinical experiences that the ciliated epithelium and glands of the nasal and paranasal mucosa do not regenerate.[11] This occurs under some conditions following a surgical procedure which destroys the periosteum or perichondrium, but it is not a condition generally found in the respiratory mucosa under the more usual conditions of injury. Matwejew [12] found that treatment with heat and acid cautery inhibited regeneration, but he reported good healing after conchotomy.

The evidence presented in this brief review of previous investigations leads to the conclusion that the mucosa of the sinuses regenerates under most conditions and that the regenerated epithelium originates from a like epithelium either from outside the sinus or from islands left after operation. There is a lack of information concerning the early stages of the regenerative process, the definite origin of epithelial cells and glands, and the cytomorphic changes in the regenerating tissues. It is the purpose of this work to describe repair after limited trauma to the nasal mucosa with these problems in mind.

The nasal mucosa was selected instead of sinus mucosa in order that the injury might be made with the least disturbance to other tissues

9. McGregor, G.: Further Proof of the Regeneration of Mucous Membrane in Human Antrum, Arch. Otolaryng. **14**:309 (Sept.) 1931.

10. Wright, C. F.: Radical Maxillary Sinus Operation: Clinical and Histologic Findings on One Hundred Patients, Arch. Otolaryng. **12**:63 (July) 1930.

11. Yankauer, S.: The Incision for Submucous Resection, Ann. Otol., Rhin. & Laryng. **18**:833 (Dec.) 1909. Hartz, H. J.: Remarks on the Physiology and Development of the Nose and Accessory Sinuses and Nasal Reflexes with Special Reference to the Function and Importance of the Turbinated Bodies, ibid. **18**:709 (Dec.) 1909. Carter, W. W.: A Plea for More Conservatism in the Treatment of Nasal Accessory Sinus Infections, ibid. **39**:578 (June) 1930. Crow, D. A.: Comparative Anatomy of Nose as a Guide to Its Surgical and Medical Treatment, Practitioner **112**:174 (March) 1924.

12. Matwejew, D. N.: Das Regenerationsvermögen der Nasenschleimhaut nach operativen Eingriffen, Monatschr. f. Ohrenh. **63**:1293 (Dec.) 1929.

or to the environment in which the mucosa normally grows. An operation on a sinus necessarily causes destruction of the supporting tissues and change in ventilation and presents the problem of securing proper drainage. None of these conditions is important in relation to localized trauma in the more available portion of the nose.

MATERIAL AND METHODS

Lambs were selected for the experiments; only healthy animals weighing about 50 pounds (22.7 Kg.) were used. Their nasal cavities proved ideal for operation. The size of the nasal passages permitted the use of instruments without causing injury to parts of the nose other than those operated on. The structure of the nose of the sheep is comparable to that of man.[13] The mucous membrane is covered with tall pseudostratified ciliated epithelium overlying a tunica propria rich in mucous and serous glands and containing a well developed cavernous plexus. The olfactory area is small and is situated superoposteriorly in the cavity.

All operations were performed with the animal under ether anesthesia. The passages were sprayed well with a 1:1,000 solution of epinephrine chloride to produce shrinkage and to control bleeding. A section of mucosa was removed by means of a modified curet, an instrument devised specially for the experiments, which consisted of a sharp scraping blade preceded by two parallel knives at each side so arranged that the mucosa excised by drawing the instrument forward had smooth perpendicular sides and was rectangular in cross-section. The width of the injury was varied by using instruments of different sizes. The strip of tissue removed was fixed, sectioned and stained; it indicated the condition of the normal mucosa and was a measure of the depth of the injury.

Mucosa was removed from two regions of the nose: from the wall of the septum at a distance of from 7 to 12 cm. from the nostril, and from the medial surface of the maxillary concha. One cut was made in each side of the nose. The concha was used on one side and the septum on the opposite side. No ill effects were noted, either from the anesthetic or from the operation. The animals were killed by bleeding at various times after operation to give a series of regenerative periods of from six hours' to two months' duration. The head was immediately sawed open, the injuries were examined and measured, and the septum and injured concha were removed and placed in a fixing fluid.

The following fixing fluids were used:

1. Zenker's solution combined with solution of formaldehyde. Tissues fixed in this solution were decalcified in a 10 per cent solution of nitric acid. Paraffin sections were made and stained with Harris' hematoxylin and eosin, Heidenhain's iron-hematoxylin and mucicarmine or Mallory's triple stain. The last two were employed to demonstrate the cilia and mitotic figures and to differentiate mucous cells and types of connective tissue. These tissues fixed in Zenker's solution showed the entire membrane and supporting structures in their normal relation.

2. Ludford's modification of the Mann-Kopsch osmic acid technic was used. Tissues were stripped from the underlying bone or cartilage after fixation.

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13. Morrison, W.: The Use of the Fresh Sheep Head for Teaching the Technic of the Submucous Resection of the Nasal Septum, Laryngoscope **44**:59 (Jan.) 1934.

3. Tissues fixed in Bensley's acetic-osmic-bichromate mixture were also stripped from the bone. Sections were stained with methyl green and aniline fuchsin to bring out the mitochondria.

NORMAL COURSE OF REGENERATION

This description of the course and rate of regeneration is based on the repair observed after experimental injury to forty sheep. Instead of giving a detailed report of each observation, a condensed account of the behavior of the different factors concerned is given in the following sequence: (1) organization of the blood clot, (2) epithelial reaction, (3) cytologic observations, (4) regeneration of glands and (5) effect of infection.

TABLE 1.—*Protocol of Injuries to, and Regeneration of, the Septum*

Lamb	Time	Width, Mm.	Average Regeneration, Mm.* Each Side	Total	Comment
187	12 hours	4.5			Dedifferentiation
191	2 days	5.4	0.44–0.32	0.76	
186	2 days	4.0	0.3–0.4	0.7	
146	2 days	6.2	0.9–0.7	1.6	
195	3 days	1.0 to 3.2	Complete	3.2	Epithelium only removed
200	4 days	5.3	1.1–1.9	3.0	Right side
190	5 days	6.8	0.7–1.4	2.1	
196	6 days	10.1	2.3–1.4	3.7	
159	8 days	9.0	1.9–2.6	4.5	Infection
200	9 days	4.1	Complete		Left side
139	11 days	2.3	Complete		Reorganization; many goblet cells
197	13 days	6.5	Complete		
180	13 days	4.2	Complete		
185	14 days	6.3	2.5–3.0		Infection
188	16 days	6.0	Partial		Ulcer
198	18 days	7.3	Partial		Ulcer
137	21 days	4.4	Complete		
189	25 days	6.4	Partial		Ulcer
184	30 days	5.2	Complete		Very little granulation tissue
192	55 days	6.0	Complete		
194	60 days	6.0	Complete		

* The term regeneration signifies that epithelial cells are present in the denuded area and does not designate any particular stage in redifferentiation toward the original type.

Tables 1 and 2 give a brief history of each of the injuries. The data in this form correlate the width of injury with the progress and rate of epithelial regeneration.

ORGANIZATION OF BLOOD CLOT

Immediately after operation a blood clot usually forms over the injury. This clot begins to organize by the end of the first day, at which time fibrin forms a layer through the clot at about the level of the epithelium, which becomes more distinct as healing progresses. By the end of the second day connective tissue cells from the sides and bottom of the injury begin to wander into the clot. On the sixth day the basal portion of the clot is well organized. Fibroblasts and leukocytes are scattered throughout the fibrin, and the red cells in the lower portion of the clot are nearly all broken down and removed. The superficial

portion of the clot remains unorganized and is shed ahead of the developing epithelium. By the end of the seventh or eighth day the clot is completely replaced by granulation tissue, which becomes organized into fibrous scar tissue during later stages of repair. Occasionally a blood clot does not form under the conditions of the experiment, in which case the epithelium migrates down over the edges and across the floor of the injury, and its proliferation is more rapid than when a clot is present (figs. 2*A* and 3).

EPITHELIAL REACTION

The restorative process of the epithelium may be divided into four stages: dedifferentiation of uninjured marginal cells, migration of dedifferentiated cells, stratification and redifferentiation.

TABLE 2.—*Protocol of Injuries to, and Regeneration of, the Concha*

Lamb	Time	Width, Mm.	Average Regeneration, Mm.		Comment
			Each Side	Total	
187	6 hours	4.0			
191	1 day	1.6			
196	2 days	4.7	1.6-0.5	2.1	
146	2 days	2.0	1.0-0.7	1.7	
195	2 days	1.5	Complete		
190	3 days	3.5	0.7-0.7	1.4	
189	7 days	6.2	1.6-2.8	4.4	
185	8 days	2.3	Complete		
186	8 days	1.0	Complete		
148	8 days	2.0	Complete		Beginning reorganization
188	11 days	1.5	Complete		
197	13 days	5.9	Complete		
198	17 days	2.8	Complete		
137	19 days	1.0	Complete		
189	22 days	2.4	Complete		
194	30 days	4.0	Complete		

Dedifferentiation is apparent in the marginal cells as early as from six to twelve hours after injury. There is complete disappearance of goblet cells, and many of the columnar cells have lost their cilia (fig. 1). Mitotic figures are abundant at all levels of the epithelium but more in the superficial than in the deep layers. Prophase changes can be seen in some ciliated cells, but cilia are not found on cells in a later stage of division. It is interesting to note that no mitotic figures are seen in the migrating cells, which would seem to indicate that most, if not all, the cells actively crossing the denuded area are derived from the marginal epithelium and not by division of the cells which have begun to cover the injury.

The sequence of changes is altered when only the epithelium has been removed or when the epithelium has been torn from the tunica propria for a short distance from the deeper part of an injury. Flattening and migration of the pseudostratified cells take place six hours after injury and are more marked after twelve hours. Dedifferentiation accompanies this early migration, and the later stages of regeneration

follow the order of those in the deep injuries. That some cells begin migration before the completion of dedifferentiation is evidenced by the presence of flattened cells in the migratory sheet of epithelium which have a persisting crown of cilia located in the center of their surface. These cells are found as late as the second day after injury (fig. 2*C*). In later stages the migratory cells lack cilia.

The second stage, migration, begins before the completion of the first stage, dedifferentiation. The free edge of the migrating area advances usually through the clot along the course of the fibrin, splitting off the more superficial, unorganized portion of the clot. However, the epithelial sheet may pass over the clot or even under it. Invaginations

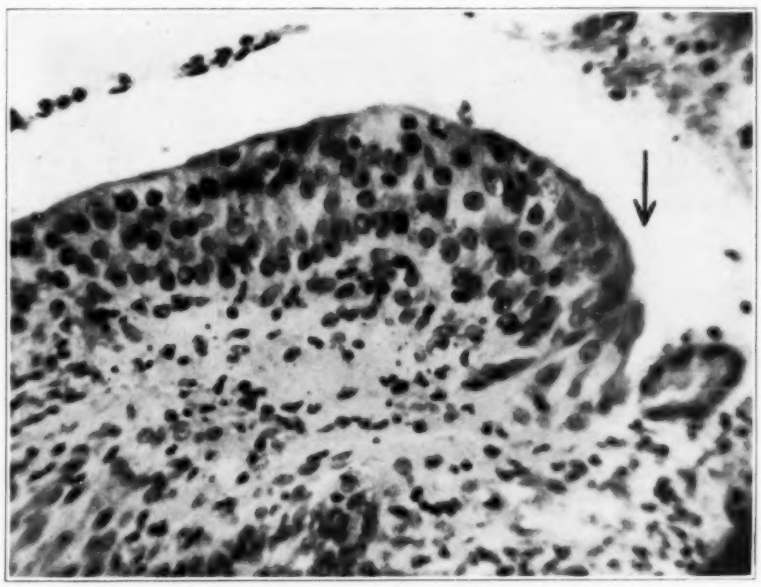

Fig. 1 (lamb 187).—Dedifferentiation from a normal pseudostratified ciliated epithelium occurred, and mitosis in epithelium bordering a deep area of injury to concha of the mucosa appeared six hours after injury. The injured area lies at the right of the arrow. Although only one mitotic figure appears in the section, four additional figures are present in the field. Note the superficial position of the mitotic figure. Migration is delayed in this area of injury; × 390.

from the advancing epithelium are sent down into the substance of the clot at irregular intervals. The distal portion of the advancing epithelial layer is ordinarily only one or two cells thick (figs. 2*A* and *B*), but when progress is apparently obstructed the cells pile up and the edge thickens several fold. The rate of advance of the migrating epithelial sheet varies greatly even in different parts of the same area of injury, being influenced by the substrata over which it passes. The average rate is approximately 3 or 4 mm. per day, the migrating area

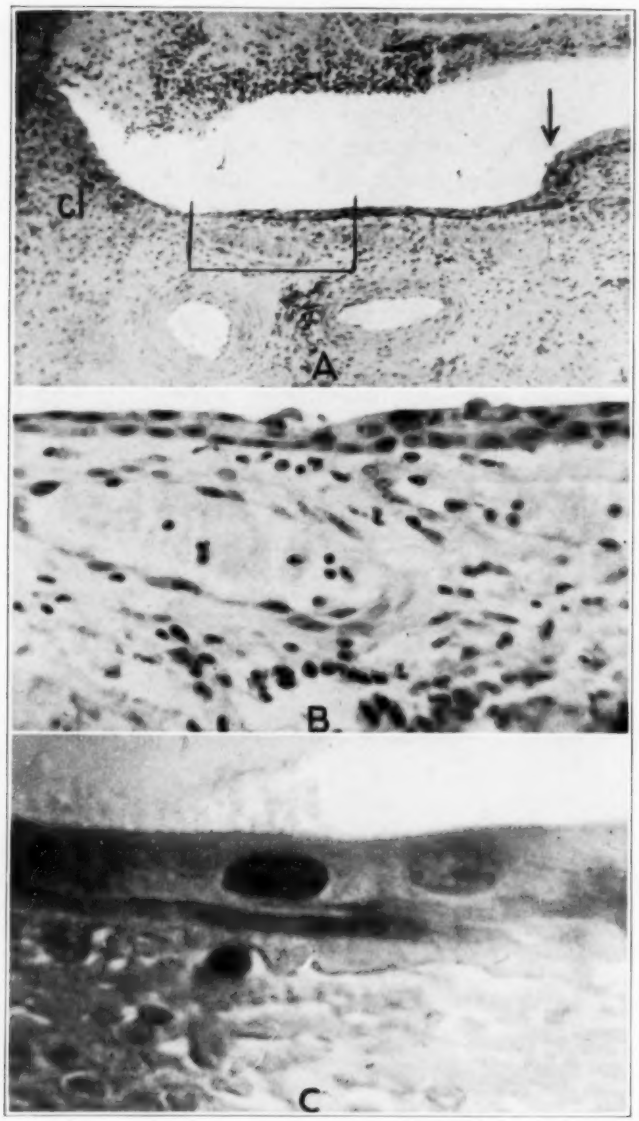

Fig. 2.—Two days after injury to the concha (lamb 196) flattened epithelial cells migrated across the tunica propria and invaded the clot (*cl*), shown at the extreme left and upper margin of *A*. The cells arise from the dedifferentiated epithelium at the right. The arrow marks the edge of the area of injury; × 100. *B* is a higher magnification (× 375) of migratory epithelium in the area marked in *A*. *C* (lamb 191) shows migration of epithelial cells before complete dedifferentiation in the area of injury to the septum. This area was the same age as that in *A*, but migration preceded dedifferentiation. Mitotic figures in the uninjured epithelium are reduced in number; × 1,500.

traveling more slowly at first during epithelial dedifferentiation and formation of the clot and more rapidly later as the clot becomes transformed into granulation tissue. This migratory area is rarely more than 3 mm. wide, owing to its rapid transformation into a stratified condition.

The third stage in the process of repair occurs when the regenerated area of epithelium, adjacent to the cut edge, begins to thicken on about the third day by stratification of the cells, which produces an epithelium which superficially resembles stratified squamous epithelium but which never becomes cornified (fig. 4). The cells composing this layer are somewhat flattened throughout, although the basal cells become cuboidal [14] as organization progresses (fig. 5). The superficial cells

Fig. 3 (lamb 195).—This is an example of healing in the absence of a clot following injury to the concha. The area covered by the migrating epithelium is much larger than that in which a clot is present. This area of injury 3.2 mm. wide, of which 1 mm. is shown, was completely covered in two days, whereas usually the distance would have been less than half of this. The injury was similar to that of which figure 2 *A* is a section. The edge of the area of injury is indicated at the arrow; × 80.

remain polyhedral and are not flattened as in true stratified squamous epithelium. This stratified area of the regenerating epithelium, originating at the injured tissue, follows closely on the thin migratory area.

14. The terms cuboidal and columnar and so on have reference to the outline of a section through the cell, not to the shape of each cell in its entirety, which may be primarily tetrakaidecahedral, as Lewis stated (Lewis, F. T.: Mathematically Precise Feature of Epithelial Mosaics: Observations on the Endothelium of Capillaries, Anat. Rec. **55**:323 [March] 1933).

Stratification progresses rapidly, and on the ninth day the site of an injury 4 mm. wide is completely covered by a layer of stratified epithelium. Mitotic figures are frequently found in the cells during the process of stratification.

Redifferentiation of the stratified cells into columnar elements begins on the eighth or ninth day and constitutes the fourth stage in epithelial regeneration. The first indication of this process is the appearance of droplets of mucigen in the cytoplasm of some of the more superficial cells, all of which become cuboidal. At all levels the cells elongate,

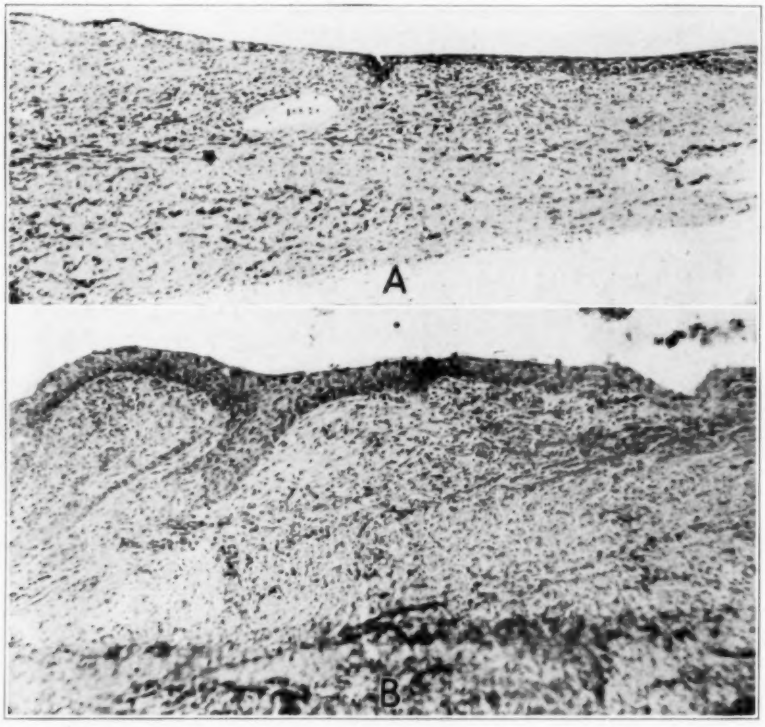

Fig. 4.—*A* (lamb 190) shows repair of injury to the septum five days after it was inflicted. Note the stratification of regenerated epithelium and organization of the clot by fibroblasts, which invade it from the walls and floor of the defect in the mucosa. The edge of the area of injury is at the extreme right of the figure; × 80. *B* (lamb 196) shows repair of injury to the septum after six days. There are more complete organization of the clot and thickening of the layer of stratified epithelium. The invaginations of epithelial cells into the clot later take part in the formation of glands. These invaginations are formed only in the earliest stages of repair, before organization of the clot; hence glands are limited to the periphery of the repaired area. The direction of epithelial migration is from left to right; × 80.

with axes perpendicular to the basement membrane, producing a stratified cuboidal layer which changes to the normal pseudostratified condition

by the extension of processes downward from the superficial cells to the basement membrane. Cilia begin to appear on the free surface of cuboidal cells at about the thirteenth or fourteenth day, although sometimes as early as the tenth day.

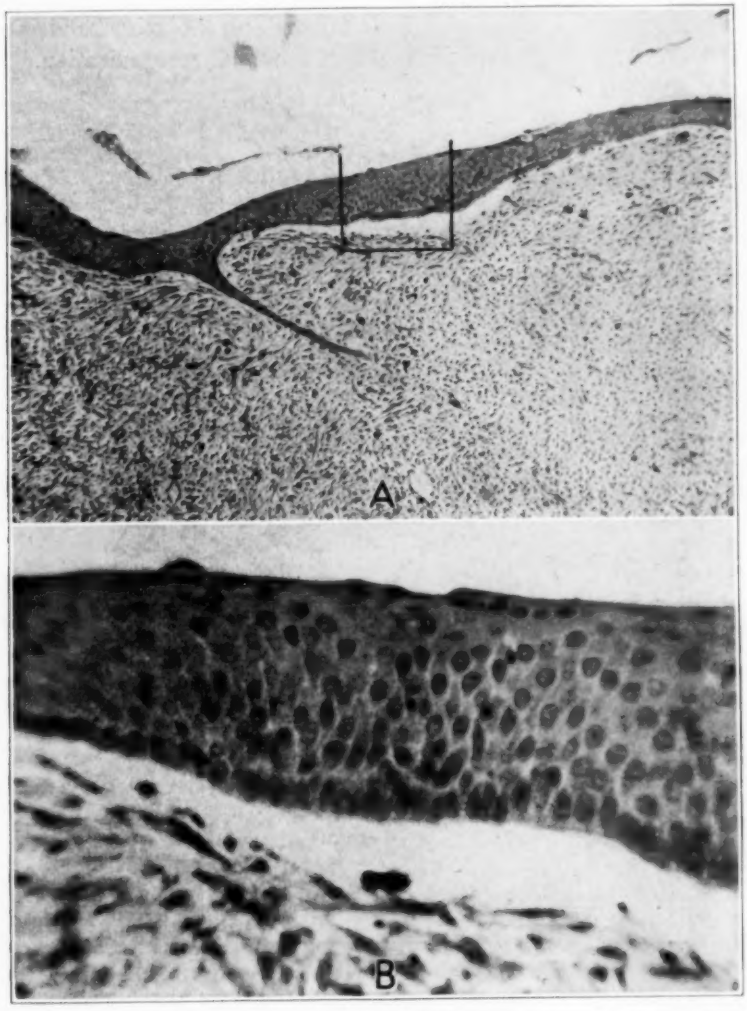

Fig. 5 (lamb 199).—*A* shows repair of injuries to the concha after seven days. The epithelial stratification is in its highest development, but the cells are still in an indifferent stage in regard to cytologic structure, as shown in figures 12 *B* and 13. Note the organization of granulation tissue at this stage; × 80. *B* shows higher magnification (× 330) of the area marked in *A*, showing details of the epithelial structure.

The reorganization of the stratified cells to the pseudostratified type takes place rather slowly (fig. 6). A 3 mm. area of injury is completely

covered by ciliated epithelium at the end of three weeks, but a wider area (4.5 mm.) still has stratified epithelium at the center. In a month all areas of injury are covered with completely regenerated epithelium.

CYTOLOGIC OBSERVATIONS

The behavior of the Golgi material and of the mitochondria was studied during the process of regeneration and reorganization. The

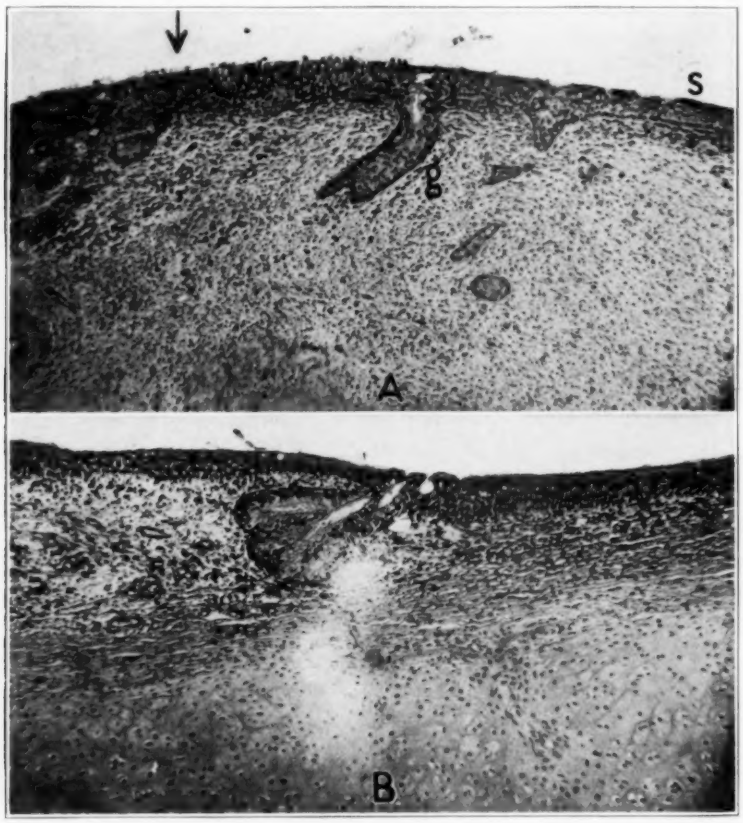

Fig. 6.—*A* (lamb 198) shows repair of injury to the mucosa of the concha after seventeen days. The epithelium adjacent to the edge of the injury (at the arrow) is redifferentiated into a pseudostratified, ciliated type. The epithelium over the center of the regenerated area (*s*) is still stratified. The gland anlagen (*g*) at the center of the figure shows the formation of a lumen by rearrangement of cells at the periphery of this epithelial invagination; × 80. *B* (lamb 194) shows repair of injury to the septum two months after operation. The epithelium is normal but overlies a tunica propria of scar tissue. Note the avascularity. The branched gland lined with ciliated and goblet cells similar to surface epithelium represents the most complete regeneration of a gland observed in the experiments; × 80.

Golgi material in normal pseudostratified epithelium of the trachea has been well described by Kopsch.[15] The present observations on the nasal respiratory epithelium confirm this. A well developed network is present in the distal cytoplasm of ciliated cells; in goblet cells this is proximal to the mass of mucigen globules. In the intermediate and basal cells the network is less extensive and is crowded about the distal end of the nucleus. In the dedifferentiated cells, which begin to migrate from the edge of the injury, the Golgi material loses its polarity and becomes evenly dispersed around the nucleus. At the same time it breaks up

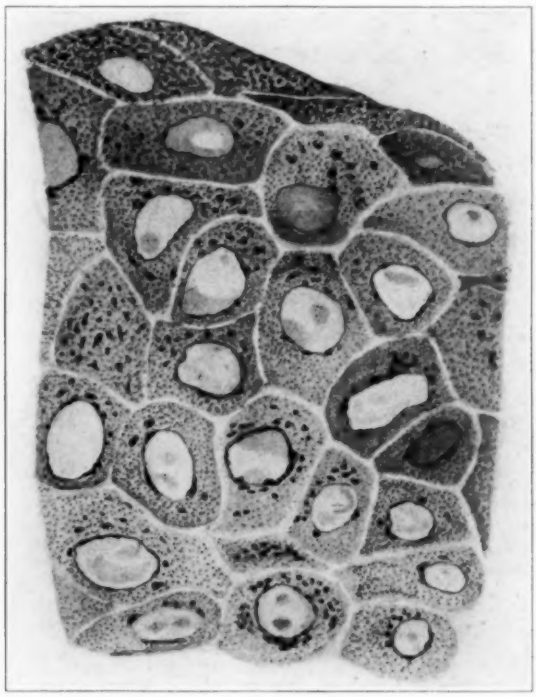

Fig. 7 (lamb 180).—The drawing shows dispersal of Golgi material in the cells of the stratified area of regenerating epithelium thirteen days after injury to the septum; × 1,150.

into many isolated Golgi bodies. This form is retained throughout the period of migration and during the subsequent formation of stratified epithelium (fig. 7) and is indicative of lack of organization and cellular polarity, in contrast to normal stratified squamous epithelium, in which the Golgi material is located on the distal side of the nucleus. Redifferentiation of the epithelium is accompanied by rearrangement of the

15. Kopsch, F.: Das Binnengerüst in den Zellen einiger Organe des Menschen, Ztschr. f. mikr.-anat. Forsch. **5**:221, 1926.

Golgi substance, that is, by its concentration at the distal pole of the nucleus. This change occurs just before the cells begin to assume a columnar shape.

Mitochondria in the normal pseudostratified epithelium are found in the form of filaments, rods and granules grouped in the same distal position, with only a few scattered through the remaining cytoplasm. The filamentous form is most abundant. The mitochondria in the intermediate and basal cells, though more evenly distributed, tend to accumulate at both poles of the nucleus, the basal cells sometimes having dense aggregations near the basal membrane.

During dedifferentiation, the mitochondria, chiefly in the form of granules, are dispersed evenly throughout the cytoplasm (fig. 8*A*). A definite decrease in number is apparent in the cells of the migratory

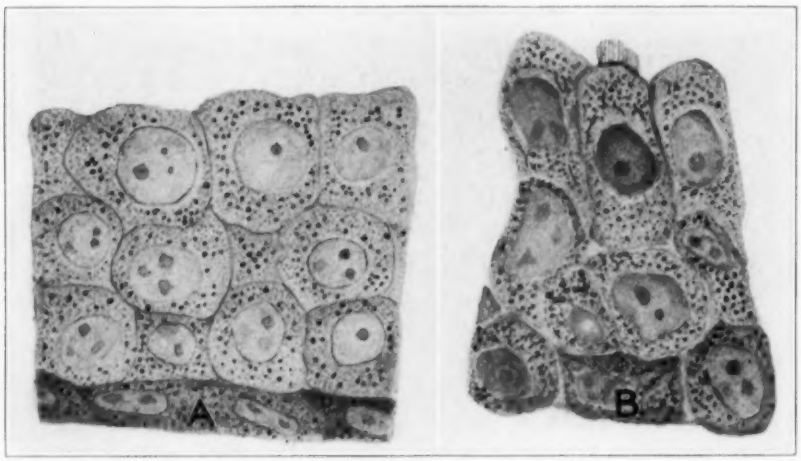

Fig. 8 (lamb 159).—*A* shows diffuse scattering of granular mitochondria in stratified cells of the regenerating area fourteen days after injury; × 1,150. *B*, shows the return of the mitochondria to normal position during the reorganization of stratified to pseudostratified epithelium. This section was taken from the same area of injury as *A* but nearer to the edge and consequently in a more advanced stage of regeneration; × 1,150.

and stratified areas during epithelial regeneration. Redifferentiation is accompanied by an increase in mitochondria and rearrangement into the normal distribution (fig. 8*B*). The distal accumulation in the superficial cells occurs before the appearance of cilia.

The technic employed failed to show the actual process of loss and regeneration of cilia. The cilia are usually lost before the cells begin to migrate, but, as already stated, in at least one instance they were present on cells in the migratory area two days after the injury. Just before the reappearance of the cilia the free surface of the cell becomes

arched, the mitochondria group themselves between the surface and the nucleus and the Golgi material takes up its position at the distal end of the nucleus. The cell at this time is cuboidal and rests on several layers of deeper cells. Its shape changes rather rapidly, elongating until it extends down to the base of the epithelium.

The development of mucous cells in the epithelium sometimes precedes and sometimes follows the origin of the ciliated cells. Granules of mucigen could be seen forming in the surface cells as early as the eighth or ninth day, before the cells reorganized from their stratified condition. Deeper cells in the stratified epithelium occasionally become filled with mucigen. The fate of these deep mucous cells is somewhat uncertain, but a comparative study of several areas of injury showed that they may become the locus for the formation of intra-epithelial glands or during the reorganization of the epithelium may reach the surface as goblet cells.

REGENERATION OF GLANDS

Few glands were found in the regenerated membrane after the periods of healing. Those observed may be divided into two classes according to their location: intra-epithelial and subepithelial glands.

Intra-Epithelial Glands.—Hollow spaces sometimes containing masses of leukocytes appear irregularly scattered among the epithelial cells during epithelial stratification, which, when observed in serial sections, are seen to communicate with the surface by small pores. The number of cavities varies widely in different areas of injury. During the transition period, when the epithelium is changing from the stratified to pseudostratified columnar type, the cells lining the cavities also change from flattened to columnar shape, and some of them acquire cilia. The remaining cells become filled with granules of mucigen and take on the appearance of ordinary goblet cells. The completely formed gland is a spherical or oval, simple alveolar type, lined with ciliated columnar cells interspersed with goblet cells and opening to the surface by a very short duct. The lumen varies in diameter from 40 to 75 microns.

Glas [16] described intra-epithelial glands in cases of hyperplastic nasal epithelium and polyps. The glands occurred frequently in the absence or paucity of subepithelial glands. The formation of glands in the nasal epithelium of lambs also attends the deficiency of subepithelial glands subsequent to regeneration of the mucosa. The cysts which Glas described as occurring in the epithelium and containing wandering leukocytes are similar in appearance to the cavities, or intercellular vacuoles, found in the regenerating epithelium.

16. Glas, E.: Ueber intraepitheliale Drüsen, Cysten und Leucocytenhäufchen der menschlichen Nasenschleimhaut, Arch. f. Laryng. u. Rhin. **16**:236, 1904.

Whether all the intra-epithelial glands present in the regenerated epithelium originate from these cavities lined by undifferentiated cells cannot be determined with certainty. Since the glands are more frequent in thirty and sixty day stages of regeneration than are cysts in the earlier stages, other sources were sought. The occurrence of occasional deep mucous cells among the interstitial cells in the transition period suggests the formation of glands by mucoid degeneration followed by cellular reorganization.

Cordes [17] described similar structures in the epithelium of the nasal passages, which when observed in serial sections proved to be horizontal ducts of subepithelial glands. In my sections only one such connection between intra-epithelial and deep glands was found. In all other instances the glands were confined entirely to the epithelium.

Subepithelial Glands.—Although only a few glands occurred in the tunica propria, a series of stages in their development from the regenerating epithelium was established. As early as the fourth day in the process of repair cords of cells extend from the migrating epithelial sheet through the organizing clot (figs. 4*B* and 5*A*). None was seen penetrating into well formed granulation tissue, and no glands were found near the center of wide areas of injury in repaired areas, which is further proof that the deep glands arise from the early formed invaginations. The scarcity of regenerated glands is probably due to the resistance of the scar tissue to penetration by epithelial cells. This confines glands to the area over which the epithelium migrates before organization of the clot is advanced, or during the first four or five days.

Some of the cells in the invaginated cords begin to form vacuoles of mucigen by the end of the second week. The solid cord is followed by a lumen, which opens and extends downward from the surface, penetrating slowly, during which process the cells at the periphery of the cord become oriented in relation to it (fig. 6*A*). The glands are fully formed by the end of one month (fig. 6*B*). They are either simple tubular or branched. Most of them are straight, but some are coiled slightly. The lumen is large and lined with cells similar to those of the epithelium of the surface. Goblet cells are interspersed among ciliated cells. The cilia of the regenerated glandular epithelium are longer than those on the surface cells, an observation which is comparable to that of Lucas [18] that cilia are longer in the ampulla of glands than on the epithelium surface of the monkey's nose.

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17. Cordes, H.: Ueber die schleimige Metamorphose des Epithels der Drüsenausführungsgänge in der Nasenschleimhaut, Arch. f. Laryng. u. Rhin. **10**:23, 1900.

18. Lucas, A. M.: Ciliated Epithelium, in Cowdry, E. V.: Special Cytology, ed. 2, New York, Paul B. Hoeber, Inc., 1932.

There was no indication of formation of new serous or mucous glands of the type found in the normal epithelium. The cells forming those glands which did occur apparently retained the properties of the epithelial cells from which they arose. It is possible that a longer period of regeneration would show a further change in the glands to a more normal type, as reported by Knowlton and McGregor [1] and Coates and Ersner [2] in the sinuses of dogs and by Semenov and Kistner [6] in the sinuses of man.

INFLUENCE OF INFECTION ON REGENERATION

Infection occurred in a number of instances after excision of a strip of mucosa, in spite of precautions taken in the operation. Septums with active ulcers or with scars resulting from ulceration were seen in animals killed eight, sixteen, twenty-five, fifty-five and sixty days after operation, affording a series of specimens of destructive and repair conditions from which it is possible to trace the process of regeneration in the presence of infection.

Two ulcers were present in the eight day specimen. They were located near the edges of the area of injury, where the perichondrium had been accidentally removed during operation. Granulation tissue covered by a stratified layer of epithelium of the undifferentiated type had advanced 2.8 mm. from one side of the area and 1.7 mm. from the other. This layer of epithelium stopped abruptly at the edges of the ulcers. Degenerative changes were not visible in the cartilage. The center of the area of injury between the ulcers was covered by bare perichondrium, no blood clot being present.

Owing to infection, the cartilage beneath the excised mucosa in the sixteen day specimen had been completely destroyed, resulting in perforation of the cartilage but not of the opposite perichondrium. Necrosis was apparently still active, as evidenced by degenerative changes and suppuration. Invading vascular areas deep in the cartilage gave the general appearance of removal of the cartilage in the formation of endochondrial bone. The width of the area of original injury was 6 mm. and that of the perforation, 4 mm. The margin of perforation of the cartilage was bordered by necrotic areas 2.4 mm. and 3.5 mm., respectively, in width.

A plate of embryonic cartilage was present beneath the uninjured perichondrium of the side of the septum opposite the ulcer. This plate tapered off at the ends to wedge-shaped portions extending between the normal cartilage and the perichondrium at each edge of the ulcer. It thus formed a callus-like splint across the opening in the cartilage, composed of a large number of fibroblasts (chondroblasts) enclosed in a matrix of light-staining substance containing a network of very fine collagenic fibers. Definite conclusions could not be drawn as to the origin of these cells from this late stage of development, but the relationship of the new cartilage to the old and to the perichondrium showed that this tissue had come from the perichondrium of the uninjured side. There was no indication that it had been preceded by granulation tissue forming the scar over the area of injury.

Granulation tissue had grown almost completely across the area of injury, and the epithelium from both sides had regenerated 3.6 mm. The epithelium exhibited a stage in redifferentiation in which many goblet cells were present.

The ulcer in the eighteen day stage was still actively destroying cartilage, which, however, had not been completely removed at any point. No new cartilage formation was present. Granulation tissue and pseudostratified epithelium had partially closed the wound, leaving an opening through which a great deal of pus was escaping.

The ulcer examined on the twenty-fifth day was similar to that observed on the sixteenth day (fig. 9). It had not been completely covered with granulation tissue and epithelium; however, the epithelium was well organized into the pseudostratified stage. The regenerating cartilage was thicker, with a deeper staining matrix than that in the earlier stage. In the two specimens examined after

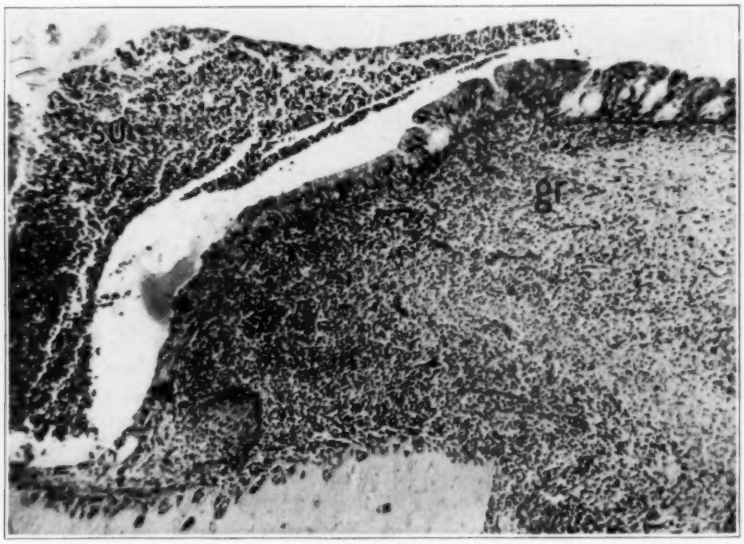

Fig. 9 (lamb 189).—This shows regeneration of the mucosa over an ulcer twenty-five days after injury. The suppurating ulcer is shown at the left (*su*). Note the destruction of cartilage in the lower left-hand corner. The regenerated granulation tissue (*gr*) and epithelium are normal for the period of repair. Ulceration retards complete repair but has little effect on the nature of the regenerated mucosa; × 80.

approximately two months, ulcers which, judging by the condition of the cartilage, had been present were completely healed over. In each, the splint of cartilage formed a pronounced elevation on the side opposite the original area of injury. The newly formed cartilage was well developed, although the matrix was still stained more lightly than that of the old cartilage and contained a definite interlacing network of fine collagenic fibrils. Vascular channels containing capillaries, arterioles and venules passed through it from the perichondrium. A new perichondrium of dense collagenic tissue was formed over its surface beneath the site of injury.

The regenerated mucosa consisted of well organized scar tissue covered with normal pseudostratified epithelium with numerous goblet cells. Subepithelial glands were present only at the edges of the original injury. Intra-epithelial glands were entirely absent in the specimen from one animal and very numerous in the specimen from the other.

The limitation of infection to the area of injury on the septum was interesting. The area of injury on the septum was usually wider than that on the concha because a larger flat surface was presented to the blade of the knife. This left a more extensive broken surface for the entrance of infective organisms. The nature of the supporting tissue beneath the injury was also important, probably more so than the extent of the injury. The septal cartilage, which was found to have been laid bare at the point of infection, having no blood supply or lymph drainage, was not as well fortified against infections as the thin turbinate bone surrounded by a rich blood supply. A third factor which may have influenced the localization of infection on the septum was its position in relation to the path of inspired air. The structure of the sheep's nose is such that air currents are directed on the medial wall, so that the area of injury receives almost the direct impact of the current and consequently its load of bacteria. The site of injury on the concha, on the other hand, is protected by its position from the direct impingement of air currents.

The time of infection could not be determined exactly, since it was spontaneous in each instance and appeared following surgical conditions similar to those in which there was no infection. The differences in degenerative changes shown in eight, sixteen, eighteen and twenty-five day ulcers indicate, however, either that infection occurred at different times following the operation or that the activity was much greater in some than in others.

COMMENT

The epithelial cells at the edge of the area of injury give rise to the regenerated membrane. Migration may start over the surface before dedifferentiation, as described by von Thonhoffer [19] in the regeneration of ciliated epithelium of the palate of the frog, or it may undergo considerable dedifferentiation first. Apparently all cells take part in the formation of the migratory sheet, with the possible exception of goblet cells. Whether the goblet cell excretes mucus during dedifferentiation of the epithelium and loses its identity or whether it disappears completely was not indicated in the sections. No cells charged with mucigen were identified in the dedifferentiating area. Ciliated cells and basal cells were flattened in the early migratory area. Evidence was presented

19. von Thonhoffer, L.: Untersuchungen über die Mitose der Flimmerzellen und der Regeneration des Wimperepithels, Ztschr. f. d. ges. Anat. **90**:713, 1929.

in one specimen that glands cut through in making the incision may contribute to the formation of the migratory sheet.

Striking alterations take place in the cytoplasm as the cells change their shape and revert to a nonpolarized type of organization. The Golgi material, previously disposed in a well formed network and restricted to the distal poles of the cells, breaks up into small masses, which become dispersed throughout the cytoplasm. Later, as regeneration progresses and the cells undergo specialization, these small particles of Golgi material take up their old position in the distal cytoplasm and fuse to form a characteristic network, such as that which existed in the first place. Evidence has been presented that with reversal in the polarity of epithelial cells the Golgi material moves from one pole to the other.[20] Some workers, however, do not share this view.[21] It is interesting that in the healing of wounds in the nasal mucous membrane there occurs a modification of the Golgi material not hitherto reported, with loss and resumption of polarity. The mitochondria share in the change; they spread to all parts of the cytoplasm and then return to their original position in the distal cytoplasm.

Since the migrating cells apparently do not multiply by mitosis, they must be replaced from behind as they push forward over the denuded surface. Mitotic figures are, on the contrary, frequently seen in the dedifferentiating cells of the uninjured epithelium. Prophase division stages can be found in ciliated cells, but in later stages of division the cilia are lost. Kindred [22] observed the same process in ciliated epithelium, but von Thonhoffer [19] and Tschassownikow [23] were unable to find any sign of division in ciliated cells during regeneration. From the larger number of mitotic figures in the upper third of the epithelium, as compared with the number in the lower third, which contains mostly basal cells, it seems that these cells, most of which are ciliated in their normal condition, are the most active in the regenerative process.

The stratiform epithelium replacing the migratory sheet may be easily confused with stratified squamous epithelium. Its lack of differentiation and cornification shows that it is composed of cells in an indif-

20. Cowdry, E. V.: The Reticular Material as an Indicator of Physiologic Reversal in Secretory Polarity in the Thyroid Cells of the Guinea-Pig, Am. J. Anat. **30**:25 (Jan.) 1922. Beams, H. W., and King, R. L.: The Golgi Apparatus in the Developing Tooth, with Special Reference to Polarity, Anat. Rec. **57**:29 (Aug.) 1933.

21. Kirkman, H., and Severinghaus, A. E.: Nature of Golgi Apparatus, Physiol. Rev., to be published.

22. Kindred, J. E.: Cell Division and Ciliogenesis in the Ciliated Epithelium of the Pharynx and Esophagus of the Tadpole of the Green Frog, Rana Clamitans, J. Morphol. **43**:267 (March) 1927.

23. Tschassownikow, S.: Ueber Becher- und Flimmerepithelzellen und ihre Beziehungen zueinander, Arch. f. mikr. Anat. **84**:150 (Jan. 10) 1914.

ferent stage. The stratified epithelium described by some authors in the regenerating membranes of accessory sinuses is undoubtedly of this type and is not due to transplantation of squamous cells. The squamous epithelium reported in the healing of a tracheotomy wound by Richards and Glenn [24] was probably due to a lack of time for complete reorganization, assuming the healing process in the trachea to be comparable to that in the nose. The squamous epithelium described by Kistner [7] and Semenov and Kistner,[6] however, was characteristically stratified squamous epithelium, and its origin from the buccal membrane could be definitely traced.

Other examples may be cited in which typical stratified epithelium succeeds ciliated epithelium. Schönemann,[25] Kemler [26] and others mentioned metaplasia of the nasal epithelium to a stratified type in cases of ozena. Haycroft and Carlier [27] observed a change from the ciliated to the stratified type on the posterior wall of the trachea of kittens, caused by friction between folds of mucosa. During embryologic development of the esophagus the ciliated epithelium is replaced by the stratified squamous type, although the direct transformation is disputed.[28]

The possibilities of metaplasia of ciliated cells in other ways, together with a review of the literature, were presented by Lucas.[18] It suffices here to mention the change to goblet cells,[29] their phagocytic activity [30] and their secretory activity in certain parts of the body.

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24. Richards, L., and Glenn, F.: The Histopathologic Reactions of the Tracheotomic Wound, Arch. Otolaryng. **15**:389 (March) 1932.

25. Schönemann, A.: Die Umwandlung (Metaplasie) des Cylinderepithels zu Plattenepithel in der Nasenhöhle des Menschen und ihre Bedeutung für die Aetiologie der Ozaena, Virchows Arch. f. path. Anat. **168**:22 (May 3) 1902.

26. Kemler, J. I.: Ozena, Arch. Otolaryng. **10**:61 (July) 1929.

27. Haycroft, J. B., and Carlier, E. W.: Note on the Transformation of Ciliated into Stratified Squamous Epithelium as a Result of the Application of Friction, Quart. J. Micr. Sc. **30**:519 (Jan.) 1890.

28. Neuman, E.: Flimmerepithel im Oesophagus menschlicher Embryonen, Arch. f. mikr. Anat. **12**:570, 1876; Die Metaplasie des fötalen Oesophagusepithels, Fortschr. d. Med. **15**:366 (May 15) 1897; Zur Frage der Epithelmetaplasie im embryonalen Oesophagus, Arch. f. mikr. Anat. **73**:744, 1909. Schridde, H.: Ueber Magenschleimhaut-Inseln von Base der Cardialdrüsenzone und Fundusdrüsenregion und den unteren oesophagealen Cardialdrüsen gleichende Drüsen im obersten Oesophagusabschnitte, Virchows Arch. f. path. Anat. **175**:1 (Jan. 2) 1904. Eberth, C. J.: Verirrtes Magenepithel in der Speiseröhre, Fortschr. d. Med. **15**:251 (April 1) 1897.

29. (*a*) Saguchi, S.: Studies on Ciliated Cells, J. Morphol. **29**:217 (June) 1917. (*b*) Sternberg, H.: Beiträge zur Physiologie und Pathologie der Schleimhaut der Luftwege: I. Die Verängerung der Nasenschleimhaut bei ausgeschalteter Nasenatmung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **7**:432, 1924. Tschassownikow.[23]

30. Ropes, M. W.: Phagocytic Activity and Morphological Variations of the Ciliated Epithelial Cells of the Trachea and Bronchi of Rabbits, Contrib. Embryol. (no. 414) **22**:77, 1930.

The redifferentiation process in regeneration is similar to that in embryonic development. Whether goblet or ciliated cells appear first in the process is apparently a matter of chance, although their development is anticipated by rearrangement of the cytoplasmic elements.

The rate of epithelial regeneration is indicated in tables 1 and 2 and also in the observations which are given later. This rate is apparently unaffected by the width or depth of the injury but is greatly modified by the nature of the surface over which migration occurs. Migration is much more rapid in the absence of a clot than in the presence of one, either in deep or in shallow injuries (lamb 195, right concha; fig. 3), though this type of healing is apparently rare in injuries passing through the basement membrane. The width of the injury is of importance in relation to the formation of subepithelial glands, because these never develop far from the uninjured tissue.

The regenerated mucosa as observed at the end of two months has normal epithelium but has failed to regenerate normal subepithelial structures. The tunica propria is fibrous, lacking the usual vascularity, and the few glands present are probably invaginations of the epithelium of the surface, having failed to regain the normal serum-secreting and mucus-secreting cells. Whether this deficiency is made good after a longer period of healing remains to be seen, as does also the direction and coordination of the surface ciliary beat. If the regeneration reached at this time marks the complete process, a nose having an entire regenerated membrane would certainly lack normal functional activity, because of decreased vascularity and secretion. On the other hand, removal of limited areas, as in my experiments, would not cause noticeable functional disturbances.

HEALING UNDER EXPERIMENTAL CONDITIONS

After having determined the method and rate of repair in the nasal passages, attempts were made to alter the process by (1) change of ventilation, (2) repeated injury, (3) irrigation and (4) application of ionization with zinc.

CHANGE OF VENTILATION

Procedure.—Operations were performed on six animals in the manner described in the study of normal regeneration. Injuries were made on the right and the left inferior concha of each of three lambs and on the right and the left side of the septum of a fourth lamb. One nostril of each was then closed by a plug of plaster. A small rubber balloon was inserted approximately 1 inch (2.5 cm.) into the nostril, inflated with plaster of paris and held firmly in position until the plaster hardened. The excess plaster and balloon were cut off even with the surface, to prevent the animal from breaking out the plug, which was held in place by the contour of the nasal vestibule. The effectiveness of the plug was tested by closing the opposite nostril and watching for leakage around it. If any

leakage was observed the plug was replaced by a new one. The lambs were killed on the seventh, tenth, fourteenth and twenty-first day, respectively.

The entire left inferior concha was removed from the two remaining lambs, and one month later injuries were inflicted on the septum on the left side and on the right inferior concha of each animal. The animals were killed on the fourteenth and twenty-eighth day, respectively, following the injury.

Results with One Nostril Plugged.—Seven Days' Regeneration.—Open Nostril (Left Concha): The area of injury was 2.5 mm. wide and extended through the mucosa to the periosteum. The removed mucosa was replaced by granulation tissue covered with a layer of stratified epithelium. At the edges of the area of injury the epithelium showed beginning reorganization, and mucous cells had begun to regenerate.

Plugged Nostril (Right Concha): An area of injury 1 mm. wide had been made in which the glandular layer was removed but the deeper blood vessels were left. Granulation tissue filled in the defect in the mucosa but was noticeably less abundant than in the area of injury on the left concha. The epithelium was stratified and showed beginning reorganization at the edges.

Eleven Days' Regeneration.—Open Nostril (Septum, Right Side): The area of injury was 1.8 mm. wide and extended down to the perichondrium. Granulation tissue filled the defect to a level even with the height of the original mucosa and was covered by stratified epithelium. The epithelium at the edges was distinctly pseudostratified and contained goblet cells and intra-epithelial glands. Numerous cords of epithelial cells extended into the granulation tissue, which contained cells provided with granules of mucigen, pointing to the beginning of organization of subepithelial glands.

Plugged Nostril (Septum, Left Side): The mucosa had been removed for a width of 2 mm. and to the depth of the perichondrium. The granulation tissue did not completely fill up the defect in the mucosa but left a depression at the site of the injury. The area of injury was covered with a thick layer of stratified epithelium undergoing reorganization. Numerous deep invaginations of epithelium were present in the granulation tissue.

Fourteen Days' Regeneration.—Open Nostril (Right Concha): The area of injury, 2 mm. wide and extending to the periosteum, was filled with granulation tissue above the level of the adjacent uninjured epithelium. It was covered with pseudostratified epithelium containing goblet cells and interspersed with ciliated cells, except near the center of the area. Intra-epithelial glands were present, containing ciliated and goblet cells.

Plugged Nostril (Left Concha): The area of injury, 1.5 mm. wide and extending down to the periosteum, was filled with granulation tissue but not enough to cause bulging of the pseudostratified epithelium with which it was covered. Ciliated and large, well formed goblet cells were present throughout its extent. Intra-epithelial glands were more numerous and better organized than on the right concha. The subepithelial glands had a large lumen lined with ciliated, nonciliated and mucigen-containing cells.

Twenty-One Days' Regeneration.—Open Nostril (Left Concha): The area of injury, 2 mm. wide and cut to the level of the periosteum, was filled with granulation tissue and covered with normal pseudostratified epithelium. Well organized subepithelial glands were present.

Plugged Nostril (Right Concha): The area of injury was 3 mm. wide and extended to the periosteum. The regenerated epithelium contained more goblet cells than were present in the area of injury in the open cavity. Subepithelial

glands were numerous and well organized, especially near the ends and sides of the area of injury. The regenerated area in this specimen was more nearly normal in its general appearance than in any specimen so far observed. Except for the central area of tissue, the site of injury could be identified only by the nature of the regenerated glands, which were in all cases composed of elements similar to those of the surface epithelium.

Results After Conchotomy.—Fourteen Days' Regeneration.—Left Side, Septum (Concha Removed): The area of injury to the septum was 2 mm. wide and extended to the depth of the perichondrium. Granulation tissue caused slight thickening of the mucosa, and it was covered with a stratified layer of epithelial cells. Redifferentiation of pseudostratified epithelium had occurred only at the edges of the area of injury, and intra-epithelial and subepithelial glands were not observed.

Right Concha (Control): The area of injury was 2 mm. wide and extended to the periosteum. A definite protrusion was produced by thick granulation tissue, which was covered with pseudostratified epithelium except at the center, where an undifferentiated stratified layer was present. Subepithelial glands occurred at the sides of the injury and already contained lumens. The healing in this specimen was considerably advanced beyond that observed on the left side of the same animal.

Twenty-Eight Days' Regeneration.—Left Side, Septum (Concha Removed): The area of injury was 3.4 mm. wide and varied in depth from the vascular to the middle of the glandular layer. Very little granulation tissue was present in the anterior (shallow) portion of the area of injury, but the deep portion had a thick layer, causing a slight bulging of the normal-appearing pseudostratified ciliated epithelium which covered it. Glands were not found in the deep part. Those in the shallow part extended straight down from the epithelium. Each had a saclike terminal enlargement.

Right Concha (Control): The area of injury was 3.3 mm. wide and reached to the periosteum. Granulation tissue formed a papilla-like protuberance at the site of injury, covered with thick pseudostratified columnar epithelium which was not completely organized at the center of the area. A few epithelial glands were present, but they lacked the usual amount of organization expected at this stage of repair. Healing was retarded.

COMMENT

Comparison of repair in the open and closed passages shows slightly better and more rapid healing in the latter. The scars in the closed cavity exhibited less formation of granulation tissue. This led to regeneration of a more even membrane. It was noted previously that the formation of subepithelial glands in the regenerated areas is roughly inversely proportional to the presence of granulation tissue; hence there is also a noticeable increase in the number of subepithelial glands present in the repaired mucosa of the closed passage.

The rate of repair was slower in the specimen taken four weeks after injury to the concha of a lamb in which the opposite concha had been removed. A logical explanation is hard to formulate, for it would seem that no increase in the air currents was brought about. In view of the large amount of granulation tissue present, it might be concluded

that a slight infection had been overcome, although no other signs of infection were present.

More goblet cells were seen throughout the membrane in the closed than in the open nostril. This result supports the observations of Hilding [31] on the noses of rabbits and dogs, that in the uninjured nasal mucosa there is an increase in the number of goblet cells in the closed nasal passage. To test further the data on goblet cells, counts were made in measured areas at comparable points on the concha and septum of the closed and open sides. There were from 40 to 65 per cent more goblet cells in the closed than in the open cavity. However, a general change was not noted from pseudostratified to stratified squamous epithelium in the open passage, as reported by Hilding. This may have been due to the short duration of the experiment or to the large size of the nasal passage of the sheep, so that an increase in air currents might not have caused any considerable mechanical irritation. The latter consideration may also explain the lack of any observable harmful effects on the respiratory organs and the freedom from fatalities, such as those reported by Anderson [32] in dogs, guinea-pigs and rabbits after plugging one nostril.

Removal of the concha produced an effect on the uninjured mucosa similar to that of closing the nostril. A count of mucous cells on the opposite side of the septum showed in each instance 50 per cent more goblet cells per unit area on the side of the septum toward the cavity from which the concha had been removed. Thus, the increase in space resulting from the removal of the concha acted like closure of the nostril, in that the air currents were slower and more diffuse.

The effect on the general mucosa in the sheep, however, was not as marked as that described by Shirota [33] after conchotomy on dogs or as that reported by Sternberg [29b] on the nasal mucosa after extirpation of the larynx of a human subject. Both observed a marked increase in goblet cells and mucoid degeneration of glands accompanied by an infiltration by leukocytes and plasma cells. No glandular degeneration and very little infiltration was observed in the sheep following removal of the concha.

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31. Hilding, A.: Histological Changes in the Nasal Mucosa Following Experimental Variation in Ventilation and Exposure, Proc. Staff Meet., Mayo Clin. **6**:772 (Dec. 30) 1931; Experimental Surgery of Nose and Sinuses: I. Changes in Morphology of Epithelium Following Variations in Ventilation, Arch. Otolaryng. **16**:9 (July) 1932.

32. Anderson, Willis S.: Nasal Obstruction: Experimental Study of Its Effects upon the Respiratory Organs and the General System, Ann. Otol., Rhin. & Laryng. **18**:467 (Sept.) 1909.

33. Shirota, G.: Experimentellen Studien über die Veränderungen der Nasengewebe nach Konchotomie, Mitt. a. d. med. Akad. zu Kioto **6**:1466, 1932.

The lack of stimulation by circulating air seemed in each instance to cause degenerative alterations in the ciliated epithelium and mucosa in general, the most constant and noticeable of which was the abundant formation of mucus-secreting cells. These mucous cells apparently originated by the degeneration or metamorphosis of cells already present, mainly ciliated cells.

REPEATED INJURY

Procedure.—Injuries made with the curet on the mucosa of the septums and concha of two lambs were repeated at three day intervals (table 3) by scraping with an instrument wrapped in gauze.

Observations and Comment.—The regenerated mucosa of all four specimens exhibited typical features of both the longer and the shorter periods of regeneration. The epithelium was pseudostratified and ciliated in each instance, except on the concha of lamb 156, in which an undifferentiated stratified layer was present over most of the injured area

TABLE 3.—*Observations on Areas of Mucosa Repeatedly Injured*

Lamb	Position of Injury	Number of Times Reinjured	Period of Regeneration	
			After Initial Injury	After Last Injury
156	Right concha	5	3 weeks	5 days
	Left septum	4	4 weeks	14 days
155	Right concha	4	5 weeks	22 days
	Left septum	4	6 weeks	29 days

(fig. 10). Regenerated glands of at least two different degrees of reorganization were present in the tunica propria. The deep glands and those near the periphery of the initial area of injury were developed to the extent usually reached by comparable structures in the controls after a similar lapse of time. Glands more superficially or more centrally located in the injured area were found to be in a stage of regeneration corresponding to that expected during the period after the final reinjury. Many of the regenerated glands and some of the original glands near the site of injury had greatly distended lumens, some of which were packed with mucous secretion. The destruction of the glandular ducts apparently led to retention of the secretion and consequent dilatation before a new opening was formed.

The general appearance of epithelium and glands in the regenerated areas led to the conclusion that the regenerated tissue was partially destroyed by each reinjury but that some regenerated tissue was left each time and continued its development without interruption. At the same time, a new regenerative process was initiated to repair the slight destruction caused by reinjury, producing areas of different stages of regeneration.

The reorganization shown four weeks after the final reinjury was in advance of that shown in the controls during the same period. There was, however, a greater irregularity of the surface, due to the underlying scar tissue.

IRRIGATION

Procedure.—The normal nasal mucosa and an area of injury to the mucosa of the septum were subjected to irrigation with one of the following fluids: distilled water, physiologic solution of sodium chloride, liquid petrolatum, castor oil and a 2 per cent solution of cocaine hydrochloride in distilled water. The irrigation was started the day following injury and repeated three times daily until the animal was killed for autopsy. At some time during this period a second injury was inflicted on the right maxillary concha of each animal, so that two periods of regeneration were observed in each.

With the exception of the solution of cocaine, all the fluids were given by introducing a nozzle into the nostril, with the head of the animal lowered. The

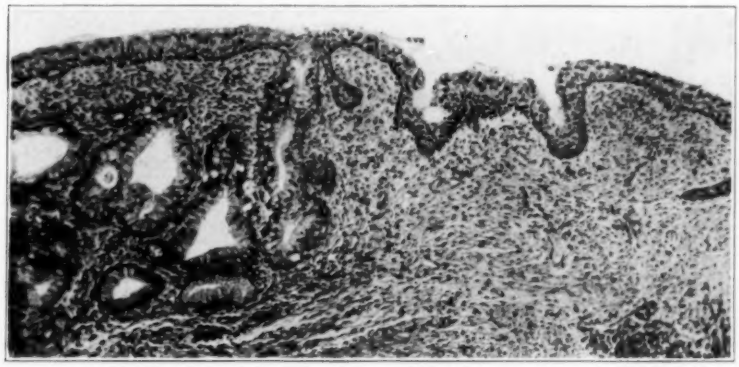

Fig. 10.—This shows the effect of repeated injury, in which destruction was less extensive each time. The right half of the field shows epithelial repair five days after the last injury; the left half shows normal deep glands and repair begun three weeks earlier at the time of the initial injury; × 75.

nostril was held closed, and the liquid was allowed to flow out the opposite nostril, insuring complete bathing of all surfaces. About 1 liter of the aqueous solutions was used at each irrigation, flowing slowly, so as to cause as little mechanical irritation as possible. The oils were employed in much smaller quantities, care being taken to prevent the animal from swallowing the irrigating fluid. Cocaine hydrochloride was applied with an atomizer. Both nostrils were thoroughly sprayed at each application.

Observations.—Animals subjected to instillation of distilled water, physiologic solution of sodium chloride or liquid petrolatum: The animals were killed eleven days after injury to the septum, which was three days after injury to the concha. These short periods of regeneration were selected in order to see if the early phases of repair were modified.

The specimen of three day injury to the concha showed normal healing, with a migrating sheet of epithelium extending out on an organized clot into which numerous fibroblasts were migrating. Each of the areas of injury to the septum

was completely covered with stratified epithelium overlying granulation tissue. A few invaginations of subepithelial glands were noted, and the epithelium showed beginning reorganization at the edges. The repair to both the three and the eleven day area of injury appeared to follow the same sequence and attain the same result in the treated as in the control animals.

Repeated irrigation did modify the epithelium in the uninjured areas of the nose. In the passages irrigated with distilled water many of the cells lacked

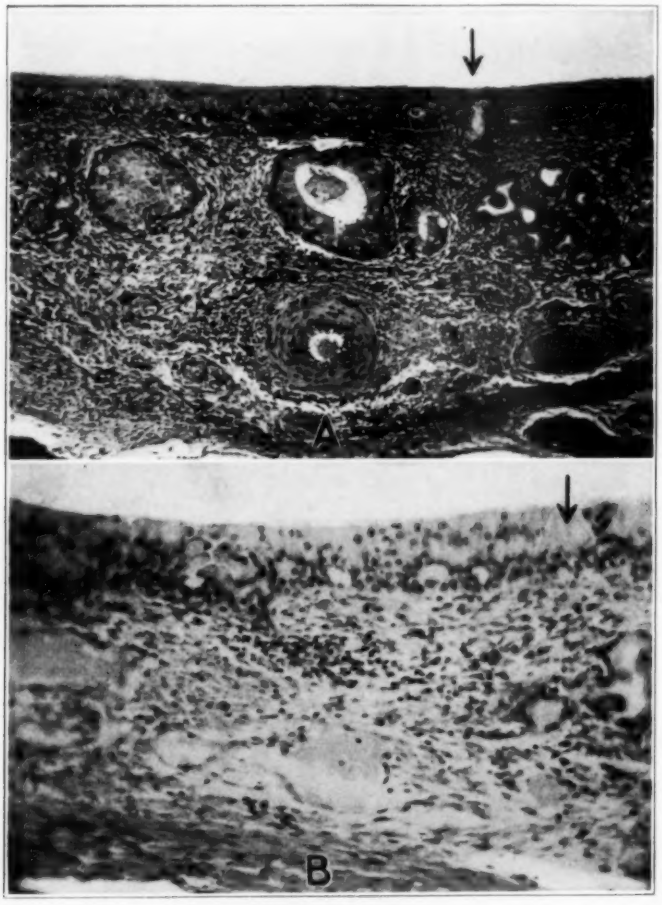

Fig. 11 (lamb 154).—*A* shows twenty-one day regeneration of the mucosa of the concha after applications of *2* per cent cocaine. The uninjured area to the right shows normal tissue. The regenerated area is to the left of the arrow, with large regenerating glands. The artery marks the depth of the excision; × 75. *B* shows thirty day regeneration of mucosa of the septum, after applications of *2* per cent cocaine. There is complete epithelial regeneration in the absence of granulation tissue. There is some infiltration by leukocytes and plasma cells. The arrow marks the right edge of the area of injury; × 150.

cilia, and there was a general tendency toward stratification. The height of the epithelium, especially on the concha, was distinctly less than that in the control

animals. In some areas the surface cells of the epithelium stained less heavily than the deeper cells. The same observations apply to passages washed with physiologic solution of sodium chloride.

The passages treated with oil, on the other hand, were lined with epithelium taller than the average in the control animals. In other respects they were normal.

Castor Oil: The injury to the concha was observed after three weeks and that of the septum after four weeks. A completely reorganized epithelium was regenerated over both areas. Subepithelial glands were more numerous in the regenerated area than in the specimens already described but there were fewer than in the specimens treated with cocaine.

The epithelium of the uninjured mucosa was taller than the average of the controls and appeared hyperplastic, although the cytoplasmic elements were normal. A few intra-epithelial spaces containing leukocytes were present, and there was an increase in the number of plasma cells and leukocytes in the tunica propria.

Cocaine Hydrochloride (2 per cent): The injuries to the concha and the septum were examined after three weeks and four weeks, respectively. The mucosa was regenerated to normal thickness and contained many branching glands lined with ciliated and mucous cells. The regenerated epithelium was taller than that of the controls but was similar to that in the uninjured areas, which was hyperplastic and contained numerous intra-epithelial glands and cysts filled with leukocytes (fig. 11).

Comment.—Liquid petrolatum, water and physiologic solution of sodium chloride had no apparent effect on the rate or quality of regeneration of the mucosa, but injured areas treated with castor oil and 2 per cent solution of cocaine hydrochloride showed more rapid and complete regeneration than the control, untreated areas of injury.

The effect of water and saline solution on the general epithelium was decidedly harmful; it was marked by a hydropic condition of superficial cells, loss of cilia and localized stratification. Stark [34] observed similar but more intense alterations in the nasal mucosa of rabbits following repeated irrigation. Liquid petrolatum brought about a slight thickening of the epithelium but no noticeable harmful effects. This supported Stark's observations on rabbits [35] in which inflammation was occasionally found, but in most instances the degenerative changes were not nearly as severe as those caused by aqueous irrigation. Fox,[36] however, found marked degeneration in the rabbit's nasal mucosa after daily instillation of liquid petrolatum over a period of nine months. Com-

34. Stark, W. B.: Irrigations with Aqueous Solutions: Their Effect on the Membranes of the Upper Respiratory Tract of the Rabbit, Arch. Otolaryng. **8**:47 (July) 1928.

35. Stark, W. B.: Effect of Mineral Oil and Solution of Ephedrine on the Normal Nasal Mucous Membrane of the Rabbit, Arch. Otolaryng. **16**:39 (July) 1932.

36. Fox, Noah: Effect of Camphor, Eucalyptol and Menthol on the Vascular State of the Mucous Membrane, Arch. Otolaryng. **6**:112 (Aug.) 1927; The Effect of Camphor, Eucalyptol and Menthol on the Nasal Mucosa, ibid. **11**:48 (Jan.) 1930.

parison of the results in sheep and rabbits is complicated by the difference in size of the nasal passages, since in the rabbit the cavity is so small that the liquids are retained for a considerable time after irrigation.

Castor oil and cocaine hydrochloride acted in the same way, stimulating regeneration in the injured area, invoking hyperplasia of the epithelium and causing general leukocytosis in the membrane. The increase in the number of regenerated glands under these forms of treatment was obvious, but I have no explanation to offer for its occurrence. The glands were similar in structure to the glands regenerated in the control areas and differed in the same way from the glands of the normal mucosa.

IONIZATION

Procedure.—Injuries to the nasal mucosa were ionized with a 1 per cent solution of zinc sulphate. The animals were partially anesthetized by the intravenous injection of 10 per cent sodium amytal (5 cc.), and the anesthetization was completed with ether. The nasal passages were thoroughly sprayed with 1:1,000 epinephrine chloride to shrink the membranes. The head was then lowered until the nasal passages were vertical, and a zinc electrode wrapped in cotton gauze, together with a rubber tube for the conduction of the solution was inserted a short distance into one nostril. Through the tube leading from an aspirator bottle slowly flowed a 1 per cent solution of zinc sulphate, which filled the nasal cavities. Excess fluid escaped from the opposite nostril. This method furnished a means of bathing the walls of the passage without traumatizing the epithelium by packing the nose. The negative electrode was attached to the bare skin of the axilla.

TABLE 4.—*Observations on Areas Treated by Ionization* *

Lamb	Location of Injury	Regeneration Before Ionization, Days	Current, Milliamperes	Time, Minutes	Milliampere Minutes	Period of Regeneration After Ionization
145	Septum	2	3	15	45	3 hours
	Concha	2	3	15	45	3 hours
147	Septum	1	5	15	150	1 day
		4	5	4†		
		7	5	11		
	Concha	1	5	15	125	4 days
		4	5	10		
153	Concha	2	5	15	75	17 days

* One per cent solution of zinc sulphate was used in each instance.
† Treatment was interrupted because of intense dyspnea.

The treatment was varied in lamb 153 by packing the passage firmly with absorbent cotton soaked in a 1 per cent solution of zinc sulphate and inserting the positive electrode into this. Two per cent cocaine hydrochloride and 1:1,000 epinephrine chloride were applied to the mucosa before packing (table 4).

Tissues obtained at autopsy were fixed in Zenker's solution combined with solution of formaldehyde; in a solution of absolute alcohol and corrosive mercuric chloride for the Feulgen test, and in absolute alcohol and solution of formaldehyde for microscopic examination after incineration.

Observations.—MACROSCOPIC CHANGES: LAMB 145.—The entire nasal mucosa appeared to be covered with a grayish-white film when removed three hours after treatment. The area of injury to the concha was covered with a clot; that on the septum was bare.

LAMB 147.—There was a copious flow of milky-white watery secretion during and after the first treatment. Breathing was labored, with both nasal passages stopped up for about an hour. At the time of the second treatment (three days later) the nose contained much thick white mucopus, especially in the right passage. Breathing was so difficult that the treatment had to be discontinued. These symptoms disappeared the following day.

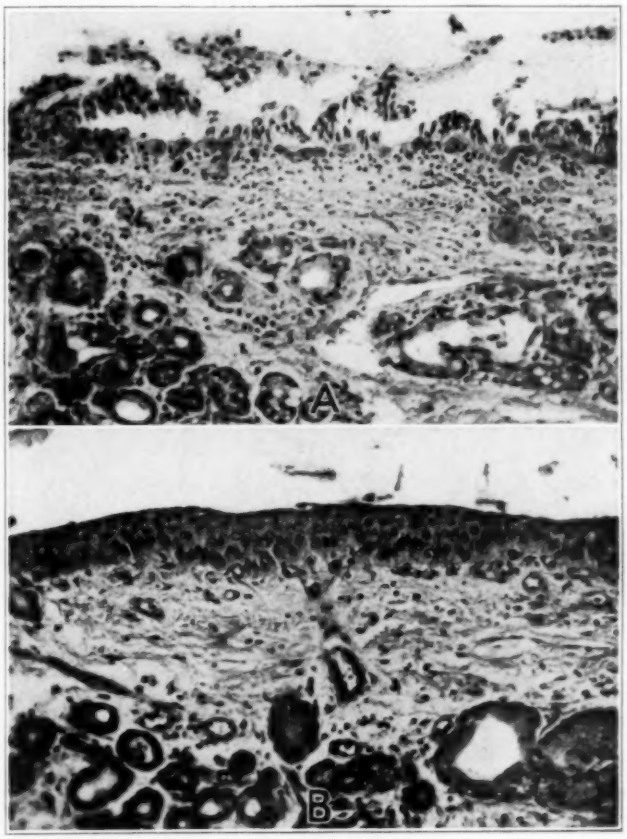

Fig. 12 (lamb 145).—*A* shows a section of mucosa of the septum three hours after ionization by zinc sulphate with 3 milliamperes of current for fifteen minutes. Note especially the engorged capillaries immediately beneath the epithelium. Epithelial destruction is apparent; × 150. *B* shows a section from the same specimen as *A* but in the region of dedifferentiation accompanying repair of an injury. Compare the resistance of the regenerating epithelium to the destructive effect of ionization with that of the normal epithelium; × 150.

At autopsy the mucosa appeared normal. The injured septum showed a raw surface apparently unhealed. A narrow white scar marked the site of injury to the concha.

LAMB 153.—The nose remained clear throughout the period after treatment, with only a slight discharge. At autopsy the mucosa was normal, and the site of injury was marked by a slightly raised scar.

MICROSCOPIC APPEARANCE: LAMB 145.—The entire epithelium, except at the site of operative injury, was in the process of disintegration (fig. 12*A*). The superficial and intermediate cells were sloughed off in clumps and singly, leaving basal cells in a broken layer on the surface of the tunica propria. In some areas the basal cells had already become flattened, forming a thin membrane. But the cells of the regenerating epithelium at the site of injury remained apparently unharmed (fig. 12*B*). Numerous mitotic figures were present and they presented the appearance of a rapidly regenerating membrane.

Changes in the tunica propria consisted of greatly enlarged capillaries immediately beneath the epithelium and large numbers of polymorphonuclear leukocytes and eosinophils in the surrounding tissue.

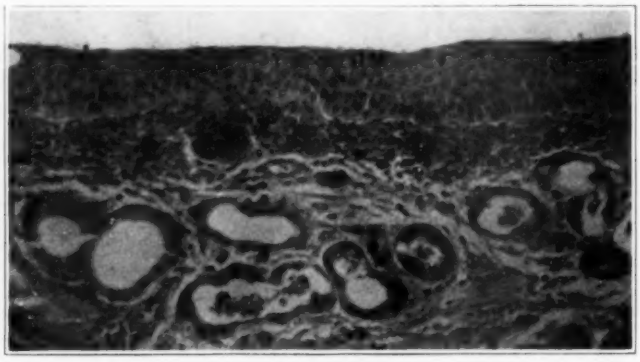

Fig. 13 (lamb 147).—Mucosa of the septum not traumatized with the curet after three ionization treatments, eight days after the first, and one day after the last, treatment. The stage of repair is similar to that of mucosa eight days following traumatic injury. The repeated ionizations do not destroy the regenerating cells replacing the epithelium removed by the first treatment; × 150.

LAMB 147.—In the area of injury to the septum of the left nostril the epithelium, exclusive of the area of traumatic injury, was of a thick stratiform type, with some infiltration of leukocytes (fig. 13). A few mucous cells were present near the lower edge of the septum.

The injury was shallow, but it was only partially covered with a thin migratory epithelium. Capillaries beneath the exposed surface of the injury were engorged with blood, and some hemorrhage had occurred near the site of injury.

In the area of injury to the concha of the right nostril the epithelium around the excised area was thicker than that in the left passage and showed a tendency toward reorganization. More mucigen-containing and ciliated cells were present. Infiltration was present but was not marked. The area of injury resulting from the excision of tissue was covered with stratiform epithelium over a thickened connective tissue stroma.

LAMB 153.—The unexcised epithelium was normal except for marked infiltration by leukocytes and for the presence of numerous intracellular spaces containing leukocytes. The tunica propria also contained many leukocytes and plasma cells. The injured area was repaired with a well organized connective tissue stroma covered by a pseudostratified ciliated epithelium (fig. 14). A few intra-epithelial and subepithelial glands were present.

Sections of mucosa from each of the lambs, when studied after incineration for microscopic examination, failed to show any change in the concentration of ash or shift in its position as compared with that in the control animals. The Feulgen reaction was also negative, in that it indicated no change in the amount or location of thymonucleic acid.

Comment.—The effect of ionization on the regeneration of the excised tissues was negligible. Healing of the septal injury in lamb 147 was slow but well within the limits of individual variation, although the repeated irritation produced by the three treatments may have had a

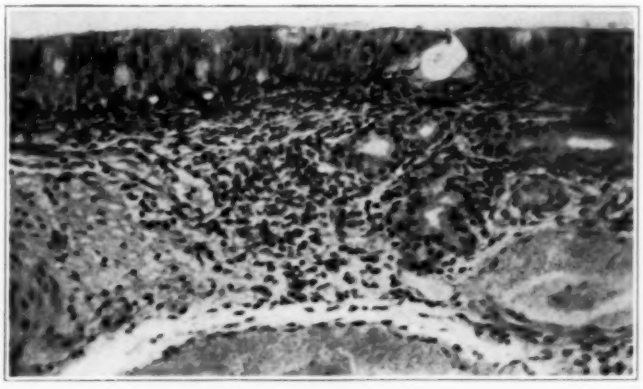

Fig. 14 (lamb 153).—Mucosa of the concha (not in the field of operation) seventeen days following a single ionization with 5 milliamperes for fifteen minutes. Note the well regenerated epithelium and infiltration in the tunica propria; × 150.

retarding effect. In other areas of injury regeneration was normal. But the experiments served to throw light on the effect of ionization with zinc on the normal nasal mucosa. The appearance three hours after treatment agreed closely with that observed by McMahon [37] after ionization with zinc sulphate of the frontal sinus of the dog, namely, sloughing of the epithelium, hyperemia and leukocytosis.

No reference to the histologic conditions of tissues at longer periods after ionization could be found in the literature. The series of four different periods after treatment observed in the three lambs gave evidence that a new epithelium was formed from the basal and interstitial

37. McMahon, B. J.: Effects of Ionization on the Mucosa of Frontal Sinuses of Dogs, Ann. Otol., Rhin. & Laryng. **43**:643 (Sept.) 1934.

cells left after the sloughing of the superficial cells. The steps in the process corresponded to those in regeneration after mechanical trauma, that is, first, a flattening and spreading of retained cells, followed by stratification and redifferentiation of a pseudostratified layer. The hyperemic condition subsided, but the leukocytic infiltration remained for at least seventeen days after treatment.

The resistance of the stratiform and migratory regenerating cells was marked. Three hours after treatment these cells at the site of operation appeared uninjured, in contrast to the general epithelium, and seemed even to be stimulated to more rapid development, as evidenced by numerous mitotic figures. This observation was further substantiated by the reactions of the epithelium surrounding the cut area, in that repeated ionization at intervals separated by a few days seemed not to remove the reorganizing epithelium induced by the first treatment. The mucosa of the septum of lamb 147, killed one day after the third treatment by ionization, was covered with a thick stratified layer which could not have been formed in this short time. Apparently any effect of repeated treatments by ionization did not produce visible changes.

It was hoped that incinerated sections of the treated mucosa would show some increase or shift in the ash content induced by the ionization; however, no differences could be seen between treated and control specimens except for those already observed in stained sections. If any zinc ions entered the mucosa they did so in such minute quantities that they could not be detected. McMahon [37] was able to force carbon particles into the epithelium by ionization or cataphoresis, and it is possible that the zinc ions also entered the mucosa, but in minute quantities, or that possibly, as suggested by Pack, Underhill, Epstein and Kugelmass,[38] the heavy metal ions transfer their charges to lighter ions in the tissue and do not penetrate.

GENERAL COMMENT

The process of repair in the nasal mucosa is similar to regenerative processes in other epithelial organs of the body. Although the migratory activity of the epithelial cells is extremely important in the early stages of repair, it will not suffice for a complete covering of a wide area of injury and is accompanied by a rapid multiplication of cells in the uninjured tissues. Arey [39] observed rapid covering of small areas of injury in the epidermis of fish and of Necturus by migration alone, which was followed by a slower period of mitotic proliferation to com-

38. Pack, G. T.; Underhill, F. P.; Epstein, J., and Kugelmass, I. N.: Experimental Studies in Electroionic Medication, Am. J. M. Sc. **167**:625 (May) 1924.

39. Arey, L. B.: Certain Basic Principles of Wound Healing, Anat. Rec. **51**:299 (Jan.) 1932.

pensate for cells lost by migration. A somewhat similar occurrence was reported by Loeb[40] in the epidermis of the guinea-pig, in which migration began immediately but was followed shortly by mitotic proliferation in the uninjured area equal to three times the normal number of mitotic figures. In the repair of the defects in nasal mucosa, however, mitosis begins soon after injury, and dividing cells are present in large numbers at the time the migratory area is as yet very small or not present. The actively migrating cells do not undergo mitosis but are replaced by cells from the uninjured region bordering the area of injury. Proliferation by mitosis in the regenerating epithelium is found later, in the stage of undifferentiated stratification.

The path which the migrating cells take in relation to the clot and connective tissue is the same as that described by Loeb; the cells follow the line of least resistance, passing over, under or through the clot. In the present experiments, however, there is no sign of sloughing of the clot after it is covered with epithelium; instead, it is replaced by connective tissue. As stated by Jorstad,[41] epithelial regeneration is more rapid in the absence of large amounts of granulation tissue.

Regeneration in the nose is similar to that in the stomach,[42] although the glandular cells play a much less important part. The same process of dedifferentiation, division of cells and migration is present, followed by reorganization into normal membrane. Glands are regenerated completely in the stomach, however, in contrast to their paucity and abnormal structure in the regenerated nasal membrane. It is possible that the nature of the substratum is the important influence, but the origin of the regenerating cells may be the deciding factor, since those in the nose are formed from the surface epithelium whereas in the stomach, it is the dedifferentiated gland cells from which the regenerating membrane chiefly arises. Consideration of glandular regeneration in the nose should await experiments of longer duration for final analysis.

SUMMARY

Normal ciliated epithelium of the lamb is regenerated after excision of parts of the nasal mucous membrane.

This epithelium rises from the dedifferentiating epithelium bordering the injured area, covers the denuded surface by migration and undergoes stratification and redifferentiation.

40. Loeb, L.: Ueber Regeneration des Epithels, Arch. f. Entwcklngsmechn. d. Organ. **6**:297 (June 14) 1898.

41. Jorstad, L. H.: Studies in Wound Healing, with Special Reference to Epithelial Hyperplasia and Its Rôle in the Process, J. Cancer Research **12**:230 (Sept.) 1928.

42. Ferguson, A. N.: A Cytological Study of the Regeneration of Gastric Glands Following the Experimental Removal of Large Areas of Mucosa, Am. J. Anat. **42**:403 (Nov.) 1928.

During migration and stratification the cells are in an indifferent stage, as shown by their cytologic structure. The Golgi material and mitochondria undergo marked morphologic changes and dispersal during this period; with the onset of reorganization they resume their original position.

Repair of the tunica propria is accomplished by the invasion of connective tissue elements into the clot, forming scar tissue which lacks normal vascularity.

Glands are regenerated by invagination of the regenerating epithelium, but they do not reach their normal degree of differentiation or of number within two months.

Infection limited to the septum delays repair and destroys underlying cartilage but does not materially alter the steps in regeneration or the final results. Cartilage regenerated from the perichondrium repairs the cartilage destroyed.

Changes in ventilation have little effect on healing but induce metaplastic alterations in the epithelium as a whole.

Irrigation with 2 per cent cocaine hydrochloride and with castor oil seems slightly beneficial to regeneration. Irrigation with other preparations had no observable effect. All irrigation causes some changes in the uninjured epithelium of the nose.

Regeneration occurs after repeated injury with only slight variation from the normal.

Ionization of 2 per cent solution of zinc sulphate in the nasal cavity destroys the general epithelium and causes leukocytosis and hyperemia but has no noticeable effect on the regeneration of tissues.

Epithelium and glandular ducts of the previously normal surface of the fossa destroyed by ionization regenerate from basal cells and epithelial fragments left after treatment. The sequence of stages is the same as that described following trauma.

Repeated ionization has no noticeable destructive effect on epithelium which regenerates after the first treatment.

MIXED TUMOR OF THE RETROTONSILLAR SPACE

REPORT OF A CASE

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A neoplasm of the mixed tumor variety may arise in many sites that are both extraparotid and extrasubmaxillary. Such growths have been reported as arising in the palate (both the hard and the soft palate), the nares, the buccal mucous membrane, the alveolar border, the base of the tongue, the face, the neck, the lips, the lacrimal gland and the larynx. Of this group, growths in and about the palate are by far the most common. New and Childrey [1] stated that in 56 per cent of their cases the tumor was found in the palate. They also noted that such a tumor rarely occurs in the tonsillar fossa. McFarland's [2] personal collection includes a group of cases of tumor involving the tonsil and the tonsillar region, although some of the growths are not definitely proved to be of the mixed tumor variety. His group includes a case reported by Bond [3] in which an encapsulated tumor removed from the region of the left tonsil, soft palate, etc., was diagnosed as an endothelioma; a case reported by Bourdon [4] in which there was a connective tissue tumor that appeared to grow from the adventitia of the blood vessels; a case reported by Browne [5] of composite tumor of the tonsil, although it did not show any evidence of a mixed tumor type; a case reported by Fry [6] of a tumor of the left tonsil, which he termed an endothelioma and, while it was not examined microscopically, was probably a mixed tumor; two cases reported by Mörch [7] in which the growth was definitely encapsulated and benign; a case reported by Quarella [8] of a large tumor of the buccal pharynx corresponding to the superior portion of the tonsil and supratonsillar fossa; a case reported by Syme [9]

From the Otolaryngological Service no. 2, Mount Sinai Hospital.
Read before the Philadelphia Laryngological Society, Feb. 5, 1935.

1. New, Gordon B., and Childrey, J. H.: Tumors of the Tonsil and Pharynx (Three Hundred and Fifty-Seven Cases): II. Adenocarcinoma of the Mixed Tumor Type (Seventy-Four Cases), Arch. Otolaryng. **14**:699 (Dec.) 1931.
2. McFarland, Joseph: Personal communication to the author.
3. Bond, J. W.: Proc. Roy. Soc. Med. (Sect. Laryng.) **9**:4, 1915.
4. Bourdon, E.: Bull. Soc. d'anat. path. **47**:317 (June) 1872.
5. Browne, G. V.: Laryngoscope **39**:663, 1929.
6. Fry, W.: West London M. J. **24**:69, 1919.
7. Mörch, P.: Acta oto-laryng. **19**:77, 1933.
8. Quarella, B.: Policlinico (sez. chir.) **24**:60, 1919.
9. Syme: From McFarland's Collection.

of a tumor of the left tonsil which was composed of connective tissue; a case reported by Wylie [10] in which the growth was an endiothelioma of the left tonsil which contained cartilage (a true mixed tumor) and was growing rapidly, and a case reported by Ono [11] of a mixed tumor of the pharynx. The scarcity of reports of this type of tumor certainly justifies the presentation of the case to be reported here.

The mixed tumor has been the subject of a considerable amount of controversy. Ewing [12] stated that "they were originally regarded as Carcinomas, while Virchow derived the cartilage from the connective tissue by metaplasia, Cohnheim regarded it as a derivative of remnants of the Branchial clefts." New and Childrey expressed the belief that a tumor of this type is the result of growth from misplaced embryonic rests and arises from the two embryonic layers of tissue—the ectoderm and the mesoderm. McFarland concurred in this view. However, some authors have expressed the opinion that the tumor may arise from the entoderm. Ewing took the stand that such a tumor may be a misplaced portion of buccal or branchial epithelium, or that superfluous duct cells may serve as the origin.

There is, moreover, a divergence of opinion as to the proper classification. In general the growths are termed mixed tumors, although New and his associates termed them adenocarcinomas. However, there is a universal agreement as to their pathogenesis. Such a tumor is potentially malignant even though it is well encapsulated; it does not tend to infiltrate the surrounding tissues and does not metastasize. Its malignant character rests on the fact that if it is not removed in toto it will recur, after which it usually grows more rapidly and also has a tendency toward metastasis to the regional and cervical lymph nodes. This metastasis may be due to a metaplasia of the original benign epithelial cells to a more active carcinomatous tissue. The latter tissue will then show more active malignant tendencies.

The mixed tumor mass is composed of epithelial and connective tissue elements that are characteristically blended. The epithelial elements may be arranged as cell strands, alveoli, neck acini or tubular structures composing a number of diffused masses of cells closely or loosely arranged. The connective tissue elements consist of fibrous connective tissue, mucous connective tissue and cartilage.

The symptoms presented are those of a slow-growing mass in the throat, painless, with only slight discomfort in the early phase. Later, as the mass becomes larger, there are the usual obstructive symptoms,

10. Wylie, A.: Proc. Roy. Soc. Med. (Sect. Laryng.) **12**:101, 1918-1919.

11. Ono, J.: Laryngoscope **44**:745 (Sept.) 1934.

12. Ewing, James: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928, p. 770.

such as difficulty in swallowing, some tinnitus if the mass extends high enough to distort or close the eustachian orifice or difficulty in breathing if the mass extends down toward the larynx. No ulceration is present, and the only characteristic is a smooth, hard swelling in the soft palate or, as in the case reported here, in the retrotonsillar region. There is no loss of weight or evidence of metastasis. In the late stage, when the growth has assumed extraordinary proportions, it may rupture through the capsule, show some areas of ulceration and even metastasize. Should metastasis occur, it is usually to the cervical lymph nodes.

The treatment is a complete surgical enucleation of the encapsulated mass. An attempt should be made to remove this mass in its entirety, for if portions of the growth remain they are prone to recur and become actively malignant. The supplemental use of either radium or high voltage roentgen therapy has not been very successful. Burnham [13] has found the use of radium or radon unsatisfactory, as the tumor cells are very radioresistant.

The prognosis is good provided complete extirpation of the mass has been carried out.

REPORT OF CASE

D. F., aged 55, was admitted to the Mount Sinai Hospital on Aug. 6, 1934, with the following history: She had apparently enjoyed good health with the exception that for the past ten years she had noticed a sensation of a lump in the right side of her throat. On numerous occasions throughout this period she had a number of physical examinations, and each time she was told to disregard the complaint. This so-called lump apparently did not cause any pain, did not increase in size and did not cause any particular discomfort on swallowing. In the last two months the lump had become definitely larger, but it still was painless. There was no loss of weight, no excessive salivation and no dysphagia, cough or hemoptysis. There were no subjective symptoms referable to the genito-urinary tract, the gastro-intestinal tract or the cardiorespiratory system. The past medical history and the social history were irrelevant.

Physical examination showed an obese woman without any apparent pathologic process other than that in her throat. The throat presented a dull congestion about the anterior pillar of the right tonsil. There was marked protrusion of the entire tonsillar region toward the midline, resembling quinsy (fig. 1 *A*), except that there was no pain, soreness or tenderness on palpation. There was a marked induration in the retrotonsillar and peritonsillar spaces. This induration was hard, almost osseous, and seemed to extend laterally into the soft tissues of the neck (fig. 1 *B*). There was no evidence of ulceration. Routine studies were made. The blood count was normal. Urinalysis gave negative results. The roentgenographic examination of the head and neck gave negative results except for a hypertrophic spondylitis involving the fifth and sixth cervical vertebrae. There was no evidence of any metastasis as seen in the roentgenogram of the chest. The provisional diagnosis was a malignant growth of the tonsil or an osteoma springing from the styloid process.

13. Burnham, C. F.: Surg., Gynec. & Obst. **45**:633 (Nov.) 1932.

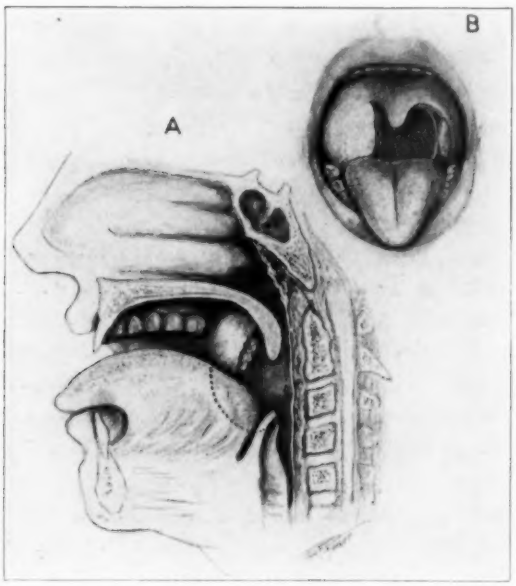

Fig. 1.—*A*, drawing depicting a lateral view of the tonsil and tonsillar region. The dotted line outlines the extent of the mass. *B*, a front view, showing the appearance of the mass in the soft tissues.

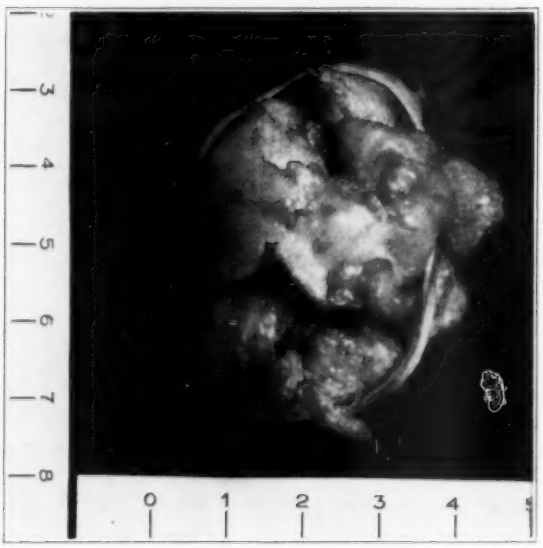

Fig. 2.—Photograph of the mass removed from the retrotonsillar space.

Two days after admission, with the area under local anesthesia (procaine hydrochloride, 1 per cent), an attempt was made to remove the mass. The tonsil was grasped and easily dissected from the capsule by the snare method. This was particularly small and apparently not diseased. However, in the retrotonsillar space there was a marked swelling which seemed to bulge through the capsule. This mass was about the size of a hen's egg. It was completely encapsulated and easily separated from the surrounding tissues by blunt dissection. It seemed to extend between the muscle sheets of the superior constrictor group of

Fig. 3.—Postoperative roentgenogram of the cervical region after injection of iodized poppy-seed oil 40 per cent to the upper limits of the retrotonsillar space.

muscles mesially and the styloid muscles laterally. It also extended up toward the base of the first vertebra and well down below the angle of the jaw.

The mass was removed almost in its entirety, with the exception of the small fragment at the lower end which appeared to encircle and be attached to the sheath of the carotid artery (fig. 2). There was no excessive bleeding, and the patient returned to bed very comfortable. The following day, a roentgenogram was taken of the area, with iodized poppy-seed oil 40 per cent injected into the upper space to determine the extent of the growth (fig. 3). A roentgenogram was also taken of the area of the tonsillar region following the application of the iodized oil

(fig. 4). Pathologic examination of the mass was made by Dr. D. Meranze, who made a diagnosis of "mixed tumor" consisting of cartilage, connective tissue and epithelial-like cells (fig. 5). The patient made an uneventful recovery while at the hospital, and up to the time of writing she has not complained of any symptoms, nor is there any evidence of induration of the mass or surrounding tissue.

Comment.—This case was one of a purely retrotonsillar tumor measuring 3.5 by 5 cm., extending up into the soft tissue of the neck and

Fig. 4.—Postoperative roentgenogram, showing the iodized oil spread over the entire cavity after removal of the tumor mass.

down below the angle of the jaw, separating the muscular sheets. The growth was well encapsulated and of the true mixed tumor variety, containing epithelial tissue, connective tissue and cartilage. There was no metastasis to the cervical lymph nodes. The tumor was easily enucleated and separated from the surrounding tissues and removed piecemeal. As my associates and I had no conception of the type of tumor, an incision was made into the mass to determine its consistency. However, the

fragments were easily removed. A small fragment was permitted to remain at the lower pole. This seemed to be attached to the carotid artery, and we hesitated to remove it for fear of injury to the vessel. While this may have been an erroneous procedure, we felt at the time

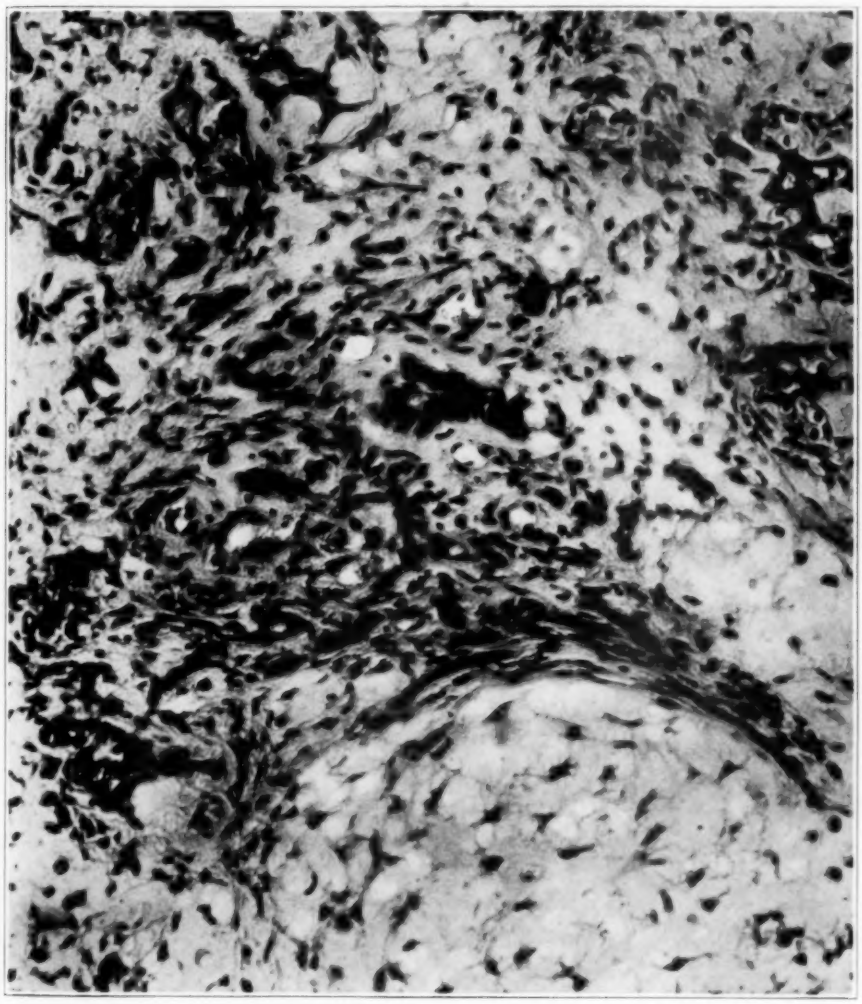

Fig. 5.—Photomicrograph showing various types of tissue.

that it would be better to play safe and keep the patient under close observation for an indefinite period of time. We did not employ any such adjuvants to treatment as x-rays or radium, as we felt that this type of tissue was only potentially malignant and that the tissue itself was very radioresistant.

SUMMARY

A case of a mixed tumor consisting of cartilage, connective tissue and epithelial cells, extending from the retrotonsillar space into the soft tissues of the neck, is reported.

Its origin may have been from a branchial cleft, from a misplaced embryonic rest or from the adventitia of the carotid sheath.

Owing to the partial enucleation, close observation will be kept up for an indefinite period.

1922 Spruce Street.

EFFECT OF PHYSICAL AGENTS ON THE TEMPERATURE OF THE NASAL SINUSES

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For a number of years I have been interested in the relative value of various forms of treatment used in the nonsurgical care of acute and subacute infections of the paranasal sinuses. The part played by heat and cold is particularly interesting, as a marked difference of opinion exists among physicians as to what happens when various methods are employed. It seemed comparatively simple to conduct some experiments which might help to determine the effect of the several methods.

A search of the literature failed to reveal any reference to work of exactly this nature. Some had been done, however, on the penetration of heat into various more solid structures, such as the orbit.

Moncreiff, Coulter and Holmquest [1] found that the penetration of heat into the orbit is greater with infra-red rays than with an electric heating pad. They expressed the opinion that the ability of the skin to tolerate heat largely determines the amount which penetrates beyond it. An additional 2 C. was tolerated by the skin when irradiated by infra-red rays than when the electric heating pad was used.

Cone [2] made some readings for the temperature of the mucous membranes of the nasal passages. He found the temperature higher in patients with infection of the sinuses and in those whose basal metabolism was above normal. The temperature was lower when the metabolism rate was low and when allergy existed.

Krukower [3] found that the temperature of the body influences the temperature of the sinuses to a slight degree, while the temperature of the outside air has very little if any effect. He also found that the temperature of the membranes is increased in the presence of acute and subacute infections but is not altered in the presence of chronic infection.

Submitted as a candidate's thesis to the American Laryngological, Rhinological and Otological Society.

1. Moncreiff, W. F.; Coulter, J. S., and Holmquest, H. J.: Experimental Studies in Diathermy Applied to the Eye and Orbit, Am. J. Ophth. **16**:193 (March) 1933.

2. Cone, A. J.: Variation in Temperature of Mucous Membrane of Nose, Arch. Otolaryng. **17**:65 (Jan.) 1933.

3. Krukower, I. M.: Veränderungen der Temperatur in der Nasen als Basis für die diagnostischen Verfahren, Monatschr. f. Ohrenh. **63**:838 (Aug.-Sept.) 1929.

Lewis and Pickering [4] found that raising the temperature of the body causes vasodilatation of the blood vessels of the extremities when these are exposed to the outside temperature while the remainder of the body is being warmed in a cabinet. They expressed the opinion that this is the means the body employs to dissipate abnormally high temperatures in isolated portions of the body.

MATERIALS AND APPARATUS

Plans were made to record the changes in the temperature of the sinuses when cold compresses, an icebag, a hot water bottle, a lamp radiating infra-red rays or hot compresses were applied to the region over the sinuses or when the whole head was heated by the high frequency oscillating current.

APPARATUS USED TO APPLY HEAT AND COLD

Small bath towels wrung out of ice-water were used for cold compresses. The ordinary commercial rubber bag filled with finely cracked ice was used for the icebag. Small bath towels wrung out of boiling water and applied to the face as soon as the skin could tolerate them were used as hot compresses. The electric heating pad was a rubber-covered heating unit, operating at 115 volts and 0.1 ampere, with a cloth outside cover. The lamp had a 260 watt bulb, with a carbon filament. The reflector was polished metal and was 7¾ inches (19.69 cm.) in diameter, and the lamp was set so that the rays would strike the cheek at right angles at a distance of 18 inches (45.7 cm.) from the bulb to the skin.

The high frequency oscillator used in these experiments was constructed on the same principle as a short wave radio transmitter, with the exception that the energy was concentrated between two condenser plates instead of being directed from an aerial. The heater was designed by the General Electric Company and consisted of a vacuum tube oscillator and rectifier that supplied the high voltage for the oscillator. The high frequency oscillator was composed of two 75 watt radiotrons operating at a frequency of from 9,000 to 12,000 kilocycles. An air-cooled transformer, having a 4,500 volt secondary rectifier and feeding a full wave rectifier, formed the 2,000 volt supply of direct current to the plate of the oscillator. The patient's head was placed between these plates, almost filling the space of 16 inches (40.6 cm.) between them. Figure 1 shows the apparatus set up, and figure 2 shows details of the hook-up.

APPARATUS USED TO RECORD CHANGES OF TEMPERATURE

To record the changes of temperature within the sinuses, a thermopile of four junctions, each consisting of a strand of no. 30 constantan and no. 30 iron wire, was used. Each junction was electrically welded, and copper wires connected the terminals of the thermopile with the registering galvanometer. The resistance of the whole assembly was found to be about 21 ohms. The individual wires were given three coats of flexible waterproof enamel and were made into a single cable by tying them together with fine silk thread. The cable was given several additional coats of enamel and was rubbed down to smooth out the rough spots.

4. Lewis, T., and Pickering, G. W.: Vasodilatation in the Limbs in Response to Warming the Body with Evidence for Sympathetic Vasodilator Nerves in Man, Heart **16**:33 (Oct.) 1931.

The cold junctions were immersed in about 5 cc. of 95 per cent alcohol contained in a small tube, which was in turn inserted through a rubber stopper. This was fitted to the top of a thermos flask filled with finely crushed ice. The flask was wrapped in vegetable wool and placed in a metal can with only the neck of the flask protruding.

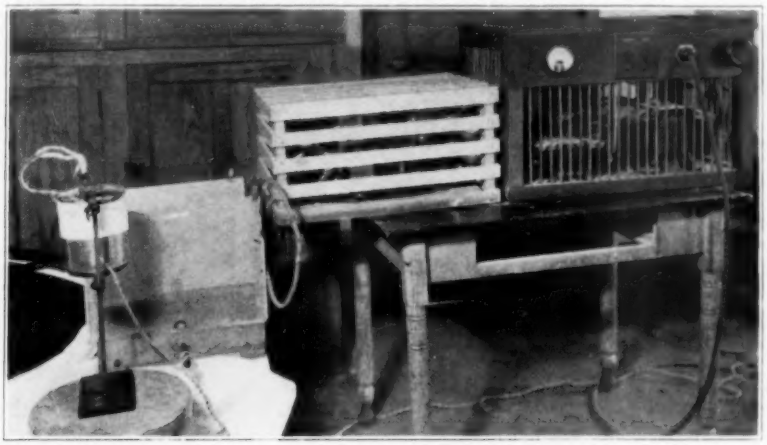

Fig. 1.—The apparatus set up for use, with the patient's head between the plates. The cold junction of the thermopile is in the foreground at the left, and the oscillator and transformer are in the middle and in the foreground to the right, respectively.

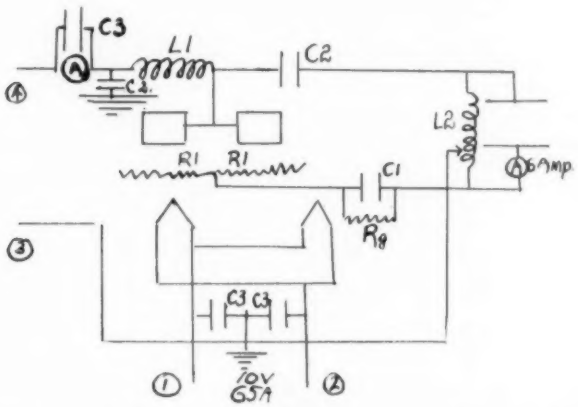

Fig. 2.—Diagram of the wiring of the 30 meter oscillator equipped with two UX 852 tubes. *A1* indicates 0-6 amperes full scale deflection thermocouple ammeter, type Do6; *A2*, 0-500 milliamperes full scale deflection ammeter, type Do4; *L1*, chock coil; *L2*, 8-turn coil copper wire, ¼ by 5/16 inch (0.64 by 0.8 cm.); *C1*, 0.002 microfarad capacity condenser UC 1014 or 1874K; *C2*, condenser UC 2224; *C3*, Faradon model T condenser, 0.01 microfarad capacity; *Rg*, large blue sticks, resistance 10,000 ohms, and *R1*, resistance, 10 volts, 6.5 amperes.

The thermo-electric voltage generated by this sensitive thermopile was found to be so great that the readings on the mirror galvanometer were pushed entirely off the scale. It was therefore necessary to bring the readings back on the scale by the application of an opposing voltage in the thermopile circuit. This current was adjusted by interposing several variable resistance units. Figure 3 shows the recording apparatus, and figure 4 shows the hook-up.

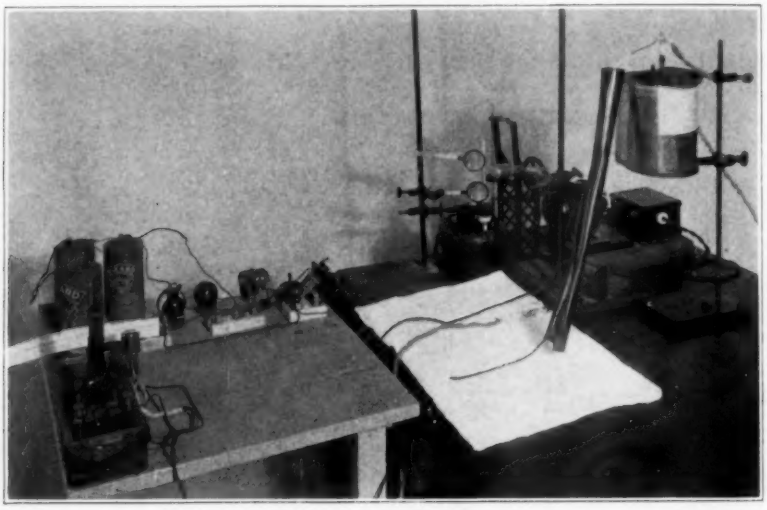

Fig. 3.—The recording apparatus, showing the galvanometer, resistance units, water bath with thermometer for checking readings, electric mixer and thermopile protected by a leather covering, with the cold junction of the thermopile in the thermos jar.

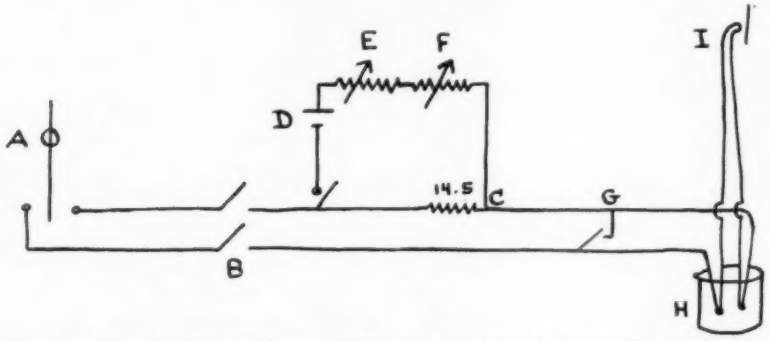

Fig. 4.—The details of the recording apparatus, showing *A*, galvanometer; *B*, switch; *C*, resistance unit; *D*, batteries; *E* and *F*, resistance units; *G*, switch to short circuit the thermopile, and *I*, the tip of the thermopile.

The thermopile was calibrated by comparison with a thermometer graduated to 0.2 F. The tip of the thermopile was loosely fastened to the bulb of the thermometer, which was immersed in water kept in constant motion by an electric stirring apparatus. Several hundred readings were made at intervals of 0.2 F. from 106 to 96 F. It was found that 1 F. averaged about 1.87 large divisions on

the galvanometer. As each large division on the galvanometer was graduated into tenths, the instrument could be read directly to about one-nineteenth of a degree Fahrenheit. The original aim in the design of the apparatus was an accuracy of 0.1 F. The surplus sensitivity merely reduced the average error. A series of readings by different observers indicated that the variations on the galvanometer per degree of change of temperature were practically the same within the limits to which the thermometer could be read and that the temperatures could be read directly from the galvanometer as equal divisions of the deflection between two end-temperatures without calibration for each intermediate interval. Before and after each experiment the thermopile was checked in water of known temperature to insure accuracy.

In several of the experiments in which the stem of the thermopile cable was directly exposed to heat or cold from the apparatus the stem was protected by several layers of thin leather. Control tests proved that heat applied to the stem of the thermopile had no effect on the reading of the instrument.

When the high frequency oscillator was used to heat the subject's head it was found that currents induced in the galvanometer circuit seriously interfered with the readings for temperature if the oscillator was close to the registering apparatus. It was necessary to move the oscillator about 50 feet (1,524 cm.) away before this difficulty was overcome. When this apparatus was used in the experiments the thermopile was placed in the patient's sinus and allowed to remain there until the readings became stabilized. It was then removed while the oscillator was in operation and was quickly replaced after the current was shut off.

When the tip of the thermopile did not completely fill the opening into the various sinuses the remaining opening was completely closed by a cotton packing.

SUBJECTS USED

When the work was first planned I intended to use animals. Later it was thought that the results might have a more practical value if the experiments were carried out on human subjects.

Three patients were used in the experiments to be described.

Patient A was a youth, aged 18, who weighed about 150 pounds (68 Kg.) and had bacterial asthma of fourteen years' duration. The septum had been resected, the antrums had been ventilated, a complete ethmoidectomy had been performed, and the anterior wall of the sphenoid sinus had been partially removed. The nose was clean, but the membranes were thickened.

Patient B was a woman, aged 22, who weighed about 125 pounds (56.7 Kg.) and had asthma of ten years' duration. She had had the same operations as those mentioned by patient A. The nose was clean, and the membranes slightly thickened.

Patient C was a man, aged 52, who weighed 150 pounds and had had asthma about twelve years. He had had the same operations as those performed on patients A and B, except that the sphenoid sinus was not opened.

None of these patients had any evidence of acute infection of the sinuses when the tests were made. Each was the subject for numerous experiments over a period of two years.

EXPERIMENTAL OBSERVATIONS

Experiment 1 (patient A).—The thermopile was placed in the right nostril. The temperature registered 92.6 F. The thermopile was then placed in the left nostril, and the temperature registered 90 F. On inspiration the temperature was

about 2 F. lower than on expiration. When the thermopile was removed the right nostril appeared to be somewhat obstructed as compared with the left nostril.

Experiment 2 (patient A; icebag).—The thermopile was placed in the right antrum. When the galvanometer readings became stabilized, in fifteen minutes, an icebag was placed on the face in the region of the right antrum. This was left in place for one hour. No definite change in the readings was recorded.

Experiment 3 (patient A; cold compresses).—The thermopile was placed in the left antrum. When the galvanometer readings became stabilized, in fifteen minutes, cold compresses wrung out of ice-water were placed on the region of the left antrum, and were changed as they warmed, for a period of one hour. No definite changes in the readings were recorded.

Experiment 4 (patient A; hot water bottle).—The thermopile was placed in the left antrum. When the galvanometer readings became stabilized, after fifteen minutes, a hot water bottle was placed on the region of the left antrum. This remained in place for one hour. No definite changes in the readings were recorded.

Experiment 5 (patient A; electric heating pad).—The thermopile was placed in the right antrum. When the galvanometer readings became stabilized, after

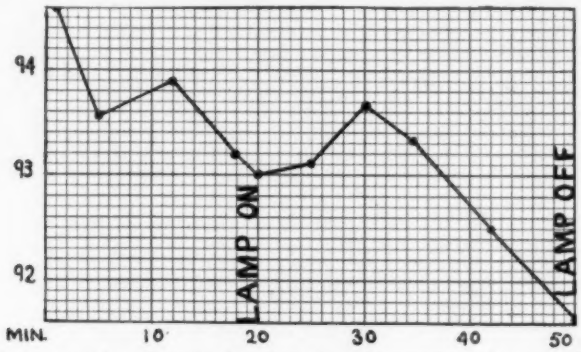

Fig. 5 (patient A).—Graph showing the observations in experiment 7. In this and the following graphs the figures along the left-hand margin refer to degrees of temperature.

fifteen minutes, the electric heating pad was placed on the region of the right antrum and the switch was turned to the high position. The pad remained in place for one hour. No definite changes in the readings were recorded.

Experiment 6 (patient A; hot compresses).—The thermopile was placed in the left antrum. After the readings were stabilized, in fifteen minutes, compresses wrung out of boiling water were applied to the region of the left antrum as soon as the skin would tolerate them. These were changed every five minutes, as they cooled, for a period of one hour. No definite changes of temperature were recorded.

Experiment 7 (patient A; radiant heat).—The thermopile was placed in the right antrum. The window was not closed with cotton. After the readings were stabilized, in fifteen minutes, the lamp was put into the position described before. The lead and the exposed portion of the thermopile were protected by several layers of leather.

After the heat had been on for twenty-two minutes, the temperature of the antrum began to drop. At the end of one-half hour the temperature had dropped 1.4 F.

After the heat had been on about twelve minutes, the patient noted an increase of drainage from the nose. When it was expelled it appeared to be serous.

Experiment 8 (patient B; radiant heat).—The thermopile was placed in the right antrum. In fifteen minutes the readings for temperature had become stabilized at 93.15 F. The heat was applied in the usual manner. After one-half hour the heat was turned off; the temperature had dropped 1.03 F. The readings were continued with the heat off. The temperature continued to drop, and in eight more minutes it had fallen an additional 0.96 F., making a total fall of 1.99 F. It then began to rise slowly.

It was necessary to remove the thermopile at this time on account of the fatigue of the patient.

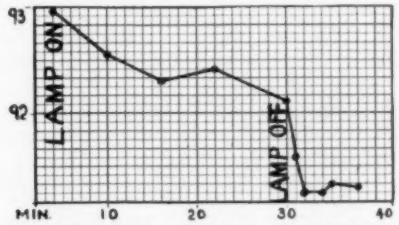

Fig. 6 (patient B).—Graph showing the observations in experiment 8.

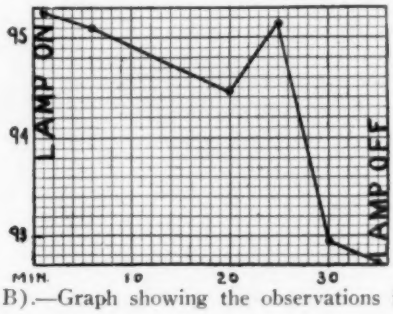

Fig. 7 (patient B).—Graph showing the observations in experiment 9.

Experiment 9 (patient B; radiant heat).—The thermopile was placed in the left antrum. After eighteen minutes, when the readings for temperature had become stabilized, the heat was directed in the usual manner to the region of the left antrum. After thirty-five minutes the temperature had dropped 2.53 F.

Experiment 10 (patient A; radiant heat).—The thermopile was placed in the left antrum. After twenty-one minutes, when the readings for temperature had become stabilized, the heat was directed in the usual manner. After the heat had been on for twenty minutes, the patient had a severe paroxysm of coughing, and the thermopile was removed. The patient began to have a moderate amount of dyspnea, and the experiment could not be continued. In the twenty minutes during which the heat was on there was a drop of 0.5 F. The following morning the patient had a rather severe attack of asthma and was compelled to remain at home for eight days.

The patient's nose was examined before this experiment was begun, and no sign of acute inflammation was noted. The temperature by mouth before, during and after the experiment was 98.4 F. The fact that there was only a limited drop

in the temperature during this test might be accounted for by the fact that the patient was obviously on the verge of an acute infection of the upper respiratory tract.

Experiment 11 (patient A; radiant heat).—The thermopile was placed in the left sphenoid sinus. In fifteen minutes the readings for temperature were well stabilized at 96.48 F. The heat was directed to the left side of the face. The temperature began to drop slowly for thirty-six minutes, when it read 94.65 F., a drop of 1.83 F. It then began to rise slowly, and after another thirty minutes it had risen to 95.42 F., a rise of 0.77 F. It was still 1.06 F. below the original reading.

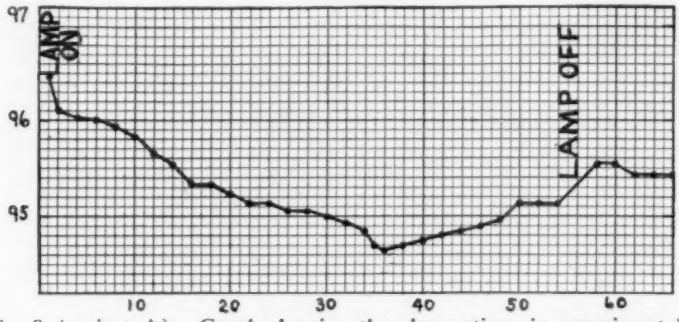

Fig. 8 (patient A).—Graph showing the observations in experiment 11.

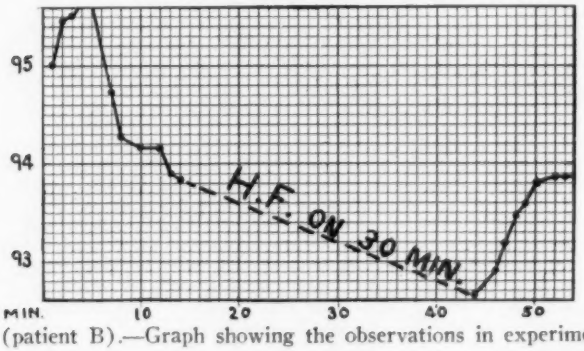

Fig. 9 (patient B).—Graph showing the observations in experiment 12.

This drop occasioned considerable surprise, as it was entirely unexpected. The thermopile was immediately recalibrated, and the readings were found to be correct.

A moderate amount of muco-serous discharge was expelled from the nose.

Experiment 12 (patient B; high frequency oscillator).—The thermopile was placed in the right antrum. It was allowed to remain there for fourteen minutes, until the temperature became stabilized at 93.85 F. The thermopile was then removed, and the oscillator was turned on. After being on for thirty minutes it was turned off, and the thermopile was quickly replaced in the right antrum.

When the readings became constant the temperature registered 92.66 F. It remained there for several minutes and then began to rise. At the end of ten minutes the temperature had returned to the original reading of 93.85 F. This was a drop of 1.19 F. after thirty minutes' exposure to the high frequency field.

The general reaction was very mild. No sweating was noted, and there was only a moderate amount of nasal discharge as compared to the profuse secretion caused by the radiant heat.

Experiment 13 (patient A; high frequency oscillator).—The thermopile was inserted in the left antrum. In twelve minutes the temperature registered 93.14 F., and remained stable at that point. The thermopile was removed and the oscillator was turned on for thirty minutes. The thermopile was replaced in the left antrum. The indicator of the galvanometer went off the scale to the right, or red side, and would not return. The thermopile was left in the antrum for fifteen minutes, but there was no registration of temperature. It was removed from the antrum and recalibrated. There was a drop of five and one-half full divisions in the calibrations. Search was made for the difficulty and a short circuit was found in the thermopile. The result of this experiment could not be determined. A reserve thermopile was used in the subsequent experiments, after many calibrations.

Experiment 14 (patient C; high frequency oscillator).—The thermopile was placed in the right antrum. After fourteen minutes the temperature was stabilized at 97.86 F. The thermopile was withdrawn, and the oscillator was turned on.

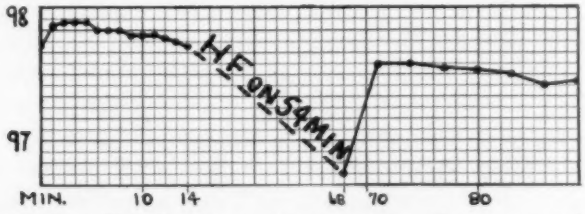

Fig. 10 (patient C).—Graph showing the observations in experiment 14.

After running for fifty-four minutes, the current was shut off, and the thermopile was quickly reinserted in the right antrum. The temperature registered 96.7 F., a drop of 1.16 F.

Experiment 15 (patient A; high frequency oscillator).—The thermopile was placed in the left sphenoid sinus. After ten minutes the temperature had stabilized. The thermopile was removed, and the oscillator was turned on. After thirty minutes, the current was turned off, and the thermopile was replaced in the left sphenoid sinus. No change in the temperature was noted. The patient felt no sense of general warmth, and the nasal secretion was very slightly increased.

COMMENT

It appears from the experiments described that cold derived from ice compresses and an icebag and heat derived from hot compresses, a hot water bottle and an electric pad have essentially no effect on the temperature of the sinuses when these agents are applied to the face. They do not appear to increase the nasal secretions perceptibly or to increase the moisture on the skin by sweating. On the other hand, the heat derived from the high frequency oscillating current and from the lamp used in these experiments apparently does cause a drop in the temperature within the sinuses and an increase in the production of sweat

on the cutaneous surfaces. This is particularly true of the radiant heat. None of the agents used caused a rise in the body temperature.

It was not a surprise to find that certain of these agents did not cause a definite reaction, but it was a great surprise to see the temperature fall when the other agents were used. It was anticipated that the infra-red rays and the high frequency current would undoubtedly increase the temperature within the sinuses, for there is ample experimental evidence to prove that heat from these agents does penetrate solid structures. Why, then, did it cause exactly the reverse to happen in the sinuses? It has been pointed out in this paper that an increase in the nasal secretions accompanied the use of the infra-red rays and the oscillating current. These are the two agents which caused a drop in the temperature. Does it not seem reasonable to assume that the loss of heat in these instances was due to the evaporation of an increased quantity of moisture? When the body is heated above a normal temperature the cutaneous surfaces are moistened by sweat. Is it not a well known fact that the respiratory tract also aids in the regulation of the temperature of the body by the dissipation of heat from its moist surface? This is particularly true in the dog and in other animals which depend almost entirely on this mechanism for the reduction of temperatures above normal. When all these facts are considered it does not seem so strange that the temperature within the sinuses should drop when certain forms of heat are applied to the face. It appears, then, that this phenomenon is apparently a part of the mechanism involved normally in the regulation of the temperature of the body.

It is not contended that heat from the lamp and from the high frequency oscillator actually reaches the membranes lining the sinuses, although there is a possibility that it does, for the same phenomenon might easily occur if the soft tissues external to the sinuses were heated and a portion of the excessive heat was dissipated from the body by way of the respiratory tract.

What about the practical application of these findings? Does it necessarily follow that because the temperature dropped when the lamp and the oscillator were used that these agents have no value in the treatment of disease of the sinuses? It is my opinion that these two agents are of great value in the treatment of acute and subacute infections of the sinuses, for it has been shown that there is a definite increase of thin serous discharge from the nose and sinuses when they are used. This obviously improves the drainage and hence hastens resolution.

SUMMARY

Cold compresses, an icebag, hot compresses, a hot water bottle, an electric heating pad and a lamp for the radiation of infra-red rays were

used to apply heat to the face in the region over the sinuses, and the whole head was heated in the field of a high frequency oscillating current of from 9,000 to 12,000 kilocycles.

Readings of the changes of temperature within the maxillary and sphenoid sinuses were made.

No changes in the temperature were noted when ice compresses, an icebag, a hot water bottle, an electric heating pad or hot compresses were used.

A drop of about 1 F. in the temperature of these sinuses occurred when the infra-red rays and the high frequency oscillating current were used. This drop was unexpected, but it was accounted for by the evaporation of the increased nasal secretions which accompanied the use of these agents.

The relative therapeutic value of these agents in the treatment of disease of the sinuses is discussed.

CHRONIC TONSILLITIS IN THE ADULT

A CLINICAL, BACTERIOLOGIC AND PATHOLOGIC STUDY

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AND

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A variance of opinion exists as to what clinically constitutes chronic tonsillitis [1] and the relationship which it bears to infections of the upper respiratory tract and certain systemic diseases. It has long been recognized that the tonsils as the site of chronic infection may be responsible for general disorders,[2] but a study of the recent literature [3] clearly shows that the mere removal of the tonsils only too often offers no panacea and indeed may have little or no influence on the subsequent course of the supposed associated disease. The uncertain status of tonsillectomy in such cases reasonably suggests a need of further investigation. With this object in view a study was undertaken to correlate the bacteriologic and pathologic observations on a group of twenty-five adult patients with a clinical diagnosis of chronic tonsillitis for whom tonsillectomy was recommended.

From the Medical, Nose and Throat and Pathological Departments of the New England Medical Center.

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2. Kahler, O.: Tonsil Problem, J. Laryng. & Otol. **48**:2, 1933.

3. Gaffafer, W. M.: Tonsillectomy and Upper Respiratory Disease, Laryngoscope **42**:385, 1932. Cunningham, R. L.: Normal, Absent and Pathologic Tonsils in Young Women: Comparison of Histories, Arch. Int. Med. **47**:513 (April) 1931. Russell, B.: Sore Throats of Other Than Tonsillar Origin, Brit. M. J. **2**:485, 1931. Logan, W. R.: Streptococcus Hemolyticus Carriers of Puerperal Sepsis: Effect of Tonsillectomy on Incidence of Organism, J. Laryng. & Otol. **47**:196, 1932. Sheldon, W.: On Acute Rheumatism Following Tonsillitis, Lancet **1**:1337, 1931. Finland, M.; Robey, W. H., and Heimann, H.: Effect of Tonsillectomy on Occurrence and Course of Acute Polyarthritis: Analysis of Six Hundred and Fifty-Four Consecutive Case Histories, Am. Heart J. **8**:343, 1933.

The clinical criteria for the diagnosis of chronic tonsillitis in this group were one or more of the following: (*a*) repeated attacks of sore throat, with or without systemic reaction; (*b*) a history of frequent or periodic sore throat in patients with diseases commonly attributed to focal infection, such as various types of arthritis, muscular rheumatism and conditions presumably of toxic origin, and (*c*) the presence of capillary injection in the faucial pillars and tonsils, together with the appearance of a purulent tonsillar exudate. Patients with disease of the sinuses or teeth were excluded from this study.

CLINICAL STUDIES

The twenty-five patients, ten men and fifteen women, selected for this study ranged from 20 to 57 years of age. Twenty-four of the patients gave a history of long-standing frequent and periodic sore throat, especially during the winter months; eleven of these had had intermittent attacks of acute tonsillitis. Twenty gave an associated history of frequent head colds. Eight gave a history of cervical lymphadenitis, but only three of these had suffered attacks of acute tonsillitis. Seven patients complained of a productive cough and two of a dry, nonproductive cough. Disorders of the ear had occurred in seven of the patients, with four complaining of tinnitus and three of chronic progressive deafness. In the latter, suppurative otitis media had been a causative factor.

Of the twenty-five patients, fourteen gave a history of one or more of the previously mentioned systemic diseases. Of these fourteen, three complained of general fatigue of undetermined etiology, and the diagnosis was general debility, presumably of toxic origin; four complained of symptoms in the muscles, such as frequent attacks of pain and stiffness, and the diagnosis was muscular rheumatism, while the other seven patients showed symptoms referable to the joints. Of the latter group, three were considered to have chronic infectious arthritis; two, acute infectious polyarthritis, and two, arthralgia. A history of rheumatic fever was obtained from four of these seven patients, and two had had scarlet fever. It is of interest that in one of these patients scarlet fever had ushered in a typical attack of acute rheumatic fever.

A clinical examination of the tonsils comprised a consideration of the size, appearance of the surface and exudate. The size of the tonsil varied greatly. The surface was as often smooth as ragged. The faucial pillars were congested in nineteen of the patients, and the tonsils were injected in four. Material could be expressed from the tonsils of twenty of the twenty-five patients; but in only one did the tonsils yield a thin, yellowish exudate, and in this material many polymorphonuclear leukocytes were noted. The material expressed from the

other tonsils often resembled pus to the naked eye, but careful microscopic examination showed only detritus and degenerated epithelial cells.

When the clinical signs were correlated with the symptoms, no single abnormality or group of changes was found to be present in all cases, nor did the findings bear a constant relation to the clinical history.

BACTERIOLOGIC STUDIES

The bacterial flora of the pharynx and tonsils has been reported variously by different observers. McCrae and Osler [4] described the lacunae of the tonsils as culture tubes in which an extraordinary number of organisms grow. Zinsser and Bayne-Jones [5] gave the following organisms as the normal inhabitants of the pharynx: staphylococci, Streptococcus viridans, Micrococcus catarrhalis, diphtheroid bacilli, pneumococci and Friedländer's bacillus. Coburn [6] in his study of infection in the rheumatic state reported the basic flora of the pharynx as follows: staphylococci, nonhemolytic streptococci and diphtheroid bacilli. Shibley, Hanger and Dochez [7] described the normal flora of the pharynx as nonhemolytic streptococci, the influenza bacillus, diphtheroid bacilli, gram-positive and gram-negative cocci and a bacillus X. Staphylococci, Streptococcus haemolyticus and pneumococci were listed as transients and were found most frequently during a cold. An increase in the incidence of hemolytic streptococci was observed also during infection of the throat. Kau,[8] studying the mechanism of focal infection in patients with chronic tonsillitis, did not recover hemolytic streptococci from the interior of the enucleated tonsil. Kilduffe and Hersohn,[9] in a study of enucleated tonsils, found hemolytic streptococci in 3 per cent and nonhemolytic streptococci in 2 per cent, staphylococci in 34 per cent, pneumococci in 54 per cent and Friedländer's bacillus in 14 per cent. Spohr [10] reported the following types of bacteria noted within the tonsils: hemolytic streptococci, 29 per cent; nonhemolytic

4. Osler, W., and McCrae, T.: Principles and Practice of Medicine, ed. 11, New York, D. Appleton & Company, 1930, p. 465.

5. Zinsser, H., and Bayne-Jones, S.: Textbook of Bacteriology, ed. 7, New York, D. Appleton-Century Company, Inc., 1934, p. 132.

6. Coburn, A. F.: The Factor of Infection in the Rheumatic State, Baltimore, Williams & Wilkins Company, 1931, pp. 156, 167, 223 and 225.

7. Shibley, G. S.; Hanger, F. M., Jr., and Dochez, A. R.: Studies in Common Cold: Observations of Normal Bacterial Flora of Nose and Throat with Variations Occurring During Colds, J. Exper. Med. **43**:415, 1926.

8. Kau, L. S.: Concerning Mechanism of Focal Infection, J. Lab. & Clin. Med. **18**:1108, 1933.

9. Kilduffe, R. A., and Hersohn, W. W.: Note upon the Bacteriology of Excised Tonsils, J. Lab. & Clin. Med. **12**:988, 1927.

10. Spohr, C. L.: Bacteriology of One Hundred Consecutive Tonsils, Ohio State M. J. **27**: 872, 1931.

streptococci, 20 per cent; staphylococci, 68 per cent, and Micrococcus catarrhalis, 10 per cent. It is obvious from the results of these investigations that the organisms within the tonsil may vary widely in incidence and character.

In this series cultures were made of material taken from three sites: (1) the surface of the tonsils before operation; (2) the depths of enucleated tonsils directly following removal, by searing and puncturing the surface, and (3) the tonsillar fossae after healing. The culture medium consisted of whole human blood agar. The incidence of types of bacteria cultivated showed Micrococcus catarrhalis to be the organism most often present, with staphylococci and nonhemolytic streptococci, second and third, respectively. On three occasions hemolytic streptococci were cultured from the surface of the tonsil but were not isolated in cultures from the other two locations. In one case the culture of the surface and crypts gave negative results for hemolytic streptococci, but these organisms were isolated from the fossae postoperatively and were found two, three and four months later. All the organisms already mentioned as occurring in the throat were found, but no flora was observed constantly in all cases nor was any characteristic type of flora found showing any relationship either to the gross appearance of the tonsil or to the clinical signs and symptoms manifested by the patient. There was a seasonal change in the bacterial flora in these cases, a fact which has been noted by others.

PATHOLOGIC STUDIES

The tonsils were examined shortly after removal. Attention was given particularly to the size, the shape, the color, the consistency and the presence or absence of superficial exudates. They were then cut longitudinally into narrow strips, each about 2 mm. thick. This permitted a thorough study of the interior of the tonsil. The freshly cut surfaces were examined for the presence of material retained within the crypts and for scars, hemorrhages, abscesses and other abnormalities. The tonsils varied in size and shape from that of an almond, 1.5 by 1 by 0.5 cm., to that of a walnut, 3 by 2 by 2 cm. The superficial and freshly cut surfaces were generally homogeneous and pale gray except for small areas of pigmentation at the site of an old hemorrhage or collection of material retained within the crypts. This retained material was usually soft and yellowish gray, rarely chalky and calcified. Grossly there were no abscesses, no areas of ulceration, no recent hemorrhages and no fibrinous or purulent superficial exudate. The consistence varied; the larger tonsils were softer and more friable and the smaller tonsils were usually firmer and cut with slightly increased resistance. The odor varied somewhat, but in none was it objectionably foul.

In brief, the gross findings, with the exception of a variation in the size and consistency and the occasional presence of retained material within the crypts, were characterized rather by the lack of pathologic change than by the presence of any one constant pathologic variation. There was no single gross pathologic change that one could correlate with any group of clinical signs and symptoms, nor was it possible from the gross appearance of the tonsil to foretell the nature of the histologic changes.

Histologic Examination.—The epithelium covering the healthy tonsil is of the stratified squamous type and possesses a moderately vascular connective tissue stroma. Crypts constitute an important part of the palatine tonsil. Near the surface these are lined with a continuation of the stratified layer of epithelial cells, but within the depth of the tonsil the epithelium gradually changes to a narrow layer composed of a single or double row of rather undifferentiated cells which extend somewhat irregularly in a branching and anastomosing finger-like manner in the form of compressed trabeculae into the adjacent underlying lymphoid tissue. The epithelium of the crypt, like that at the surface, is constantly but slowly being renewed, the older cells together with scattered underlying lymphocytes desquamating into the cavity of the crypt. Before being discharged into the oral cavity these desquamated cells may undergo regressive changes, with disintegration and transformation into amorphous cellular débris. Small quantities of this material, together with preserved epithelial cells, lymphocytes and scattered bacteria, are often seen within the crypts of healthy tonsils.[2]

For histologic study a single block of tissue cut longitudinally was removed from the center of each tonsil. The surface epithelium, the epithelium lining the crypts, the contents of the crypts, the character, size and relative number of lymph follicles, the connective tissue stroma and capsule and the large and small vessels were carefully examined. In addition, bacterial stains were used in each instance to determine roughly the site and character of organisms present within the tonsil. It is appreciated that although there may be some criticism of selecting only a single block of tissue from each tonsil for histologic examination, that in itself should not detract from the value of these observations.

Epithelium: In one third of the specimens which form the basis of this report the epithelium covering the surface and lining the crypts showed no evidence of pathologic change. In the remainder the most common pathologic change was thickening of the epithelium of the crypts, with increased desquamation and moderate retention of cellular débris within the crypts. This was frequently associated with the formation of minute retention cysts lined with squamous epithelium and filled with cornified epithelial cells, cellular débris, cholesterol crystals

and calcified granules. Such changes were frequently found in the absence of any other form of pathologic change, with the possible exception of old healed scars. Of interest in this connection were the findings in the identical sections stained for bacteria, especially as emphasis is so often placed on the importance of bacteria within the tonsil. Bacteria, both cocci and bacilli, appearing singly, in pairs and in clusters and usually mixed together and intermingled with cells, were found within all parts of the crypts. They were not more numerous at the bases than at the mouths of the crypts. A careful study of the epithelium of the crypts showed no histologic differences between the epithelium of those with organisms and that of those without organisms. Organisms were not found more commonly in crypts filled with necrotic cellular débris than in others comparatively free and empty. In some crypts distended to form small cysts through the accumulation of cellular débris, where one might expect conditions favorable for bacterial growth, organisms could not be demonstrated.

The second most common pathologic change of the epithelium, seen in one third of the specimens, was the presence of a superficial inflammatory reaction within the crypts and confined to the surface. This was characterized by the appearance of a delicate fibrinous exudate intermingled with well preserved and degenerate polymorphonuclear leukocytes, lymphocytes, mononuclear cells and scattered epithelial cells. The underlying lymphoid tissue revealed no sign of inflammation; there was even absence of congestion and edema. Of the entire series, only one tonsil revealed a small area in which the epithelial barrier between the lymphoid tissue and the cavity of the crypt was absent. There was an acute superficial inflammatory reaction at this site, with ulceration involving the underlying lymphoid tissue. It is of interest to correlate these changes with the observations on the sections stained for bacteria. There was no apparent relationship between the presence of organisms and the sites of superficial inflammatory reaction, for organisms were seen as commonly in healthy crypts as in the others. Many crypts showing a superficial inflammatory exudate were lacking in organisms. Furthermore, there was no apparent difference between the character of the underlying lymphoid tissue and its vascularity in those crypts with organisms and in those without. Frequently it was necessary to search the entire section to find a single organism. In none of the sections were organisms found within the lymphoid tissue. This correlation of the presence or absence of organisms within the tonsillar crypts with the presence or absence of histologic signs of injury to the epithelium is in no sense an attempt to belittle the importance of organisms, visible or invisible, that may lead to an inflammatory reaction. It is rather to point out that the mere finding of organisms within a tonsillar exudate

neither warrants the diagnosis of inflammation nor justifies the assumption that an infection is present.

Lymphoid Tissue: Before considering the pathologic change of lymphoid tissue of the tonsil it is to be remembered that in the so-called healthy tonsil in different persons and in the same person at different ages this tissue shows a wide range of variation. The striking regeneration after partial tonsillectomy might suggest a functional demand for this type of tissue on the part of the body. It is made up largely of follicles which vary in size and in number. There is no sharp line of demarcation separating the lymphoid tissue from the surrounding stroma. The most striking change seen in this tissue in the series was the wide variation in quantity. In some tonsils the follicles were small and comparatively few, while in others they were excessively large and greatly increased in number. There were no areas of necrosis and no abscesses, but in one tonsil, quite unexpectedly, two solitary tubercles were found within the lymphoid tissue. A constant relationship between the lymphoid tissue and the changes within the epithelium and crypts was not demonstrable.

Blood Vessels: The changes in the blood vessels were not remarkable. In three specimen cases the capillaries of the lymphoid tissue were distinctly engorged. This may have been due in part to surgical trauma. In three other specimens the small arteries within the tonsils were enlarged and had thickened walls with some intimal sclerosis. The capsule of a small vessel in one specimen of a tonsil showed in its adventitia and in the adjacent stroma a lesion resembling the granuloma of acute rheumatic fever. It is of interest that the clinical diagnosis for the patient from whom this tonsil was removed had been chronic tonsillitis and acute polyarthritis. With the exception of moderate lymphoid hyperplasia, the tonsils from this patient showed no other pathologic change.

Connective Tissue: In the majority of specimens the connective tissue of the stroma and capsule of the tonsils was increased, scarred and riddled with small and larger foci of lymphocytes. The stroma of one of the tonsils revealed a small area of degeneration and necrosis of collagen, with edema and deposition of fibrin. This tonsil showed no other pathologic lesion than a slight increase in desquamation of epithelium within the crypts. The patient from whom this specimen was removed had a clinical diagnosis of chronic tonsillitis and polyarthritis.

Comment: In summarizing the histologic observations it should first be pointed out that none of the tonsils should be regarded as absolutely "normal." Changes in the epithelium, in the content of the crypts, in the lymphoid tissue or in the vessels and the stroma were present in all specimens.

For comparison, a series of tonsils from adults who had shown no recent sign or symptom clinically of tonsillar disease were removed at autopsy and examined both grossly and histologically. It is rather difficult to define concisely from a histologic standpoint what should constitute an average healthy tonsil in an adult, for those removed post mortem revealed a wide variation in the character of the epithelium, in the amount and composition of the material within the crypts, in the quantity of lymphoid tissue and in the amount and cellularity of the connective tissue stroma. Briefly, the more outspoken variation from the so-called normal tonsil found in this autopsy material consisted of increased desquamation and proliferation of epithelium within the crypts, superficial inflammatory exudates on the surface of the crypts, secretion retained within the crypts with small cystlike formations, lymphoid hyperplasia and occasionally arteriosclerosis. Scars of healed inflammatory reactions, riddled with foci of lymphocytes, were frequently encountered. Who is there in middle life whose tonsils have not been the seat of one or more inflammatory reactions? Many of these reactions leave a scar and appreciably alter the normal microscopic structure, making a clear separation between the healthy and the diseased tonsil exceedingly difficult.

GENERAL COMMENT

It was seen from a correlation of the clinical signs and symptoms with the bacteriologic and pathologic observations that certain criteria commonly accepted as a basis for the clinical diagnosis of chronic tonsillitis offer little or no information concerning the cytologic changes found in the tonsil. A comparison of the histologic changes in this series of tonsils from patients selected clinically as having chronic tonsillitis with the changes in an equal number of tonsils removed at autopsy from a group of adults who had shown no recent indication of tonsillar disease revealed a striking similarity in the findings in the two groups. The histologic picture in each case, it is true, was variable, but this was of little wonder when one considers the past history of the patients and remembers the widely varying clinical signs and symptoms used as the basis for the clinical diagnosis of chronic tonsillitis. The problem has not been to prove that all cases in which there is a clinical diagnosis of chronic tonsillitis warrant a similar histologic diagnosis but rather to demonstrate the variety of changes which may be found in the tonsil of the patient whose condition is diagnosed in the clinic as chronic tonsillitis.

SUMMARY

Twenty-five consecutive cases in which a clinical diagnosis of chronic tonsillitis had been given were studied from a clinical, bacteriologic and

pathologic standpoint. It has been shown that from the clinical aspect a single or group of changes was not found in all the tonsils and that the clinical findings did not bear a constant relationship to the clinical history. From a bacteriologic standpoint one type of flora was not observed constantly in the tonsils nor was any characteristic type of flora found showing a relationship either to the gross appearance of the tonsil or to the clinical signs and symptoms. From the standpoint of pathology the changes in the tonsil, though variable, were strikingly similar to those in a group of selected controls. The histologic changes, with the rare exception of the specific lesion of rheumatic fever, did not bear a definite relationship to the bacterial flora or to the clinical signs and symptoms.

Abstracts from Current Literature

Ear

INFLUENZAL LABYRINTHITIS WITHOUT SUPPURATIVE OTITIS MEDIA. A. B. SMITH, J. Laryng. & Otol. **50**:263 (April) 1935.

Smith points out that a labyrinthitis in the course of middle ear suppuration is not uncommon; however, a true labyrinthitis following a meningitis of influenzal origin is extremely rare. He describes a case of what appeared to be true labyrinthitis originating from an infection with Pfeiffer's Bacillus influenzae and following an influenzal infection of the meninges, the labyrinth being involved by a spread outward along the eighth nerve. In this case an influenzal bronchopneumonia was followed by an empyema and later by a meningitis which proved fatal. Histologic examination of the left temporal bone revealed a labyrinthitis, but no symptoms of this condition were observed during life. It appears that the labyrinthitis arose after the onset of the meningitis. It is not surprising that no symptoms attributable to labyrinthitis were observed in a baby of 5 months dying from meningitis. There is little doubt that the organism producing the labyrinthine infection was Pfeiffer's B. influenzae, which was grown from the cerebrospinal fluid and from the pleural cavity. This is also substantiated by the marked hemorrhagic character of the exudate in the inner ear and in the internal acoustic meatus. A consideration of the path of infection of the labyrinth reveals some interesting points. It does not seem possible for the infection to have arisen from the middle ear. There was no perforation of the tympanic membrane, no pus was present in the tympanum, there was no catarrh of the tympanic epithelium, and there was no history at any time of a middle ear suppuration, but the large amount of subepithelial tissue present in the tympanic antrum was unusual. The absence of a purulent exudate in the tympanum of an infant of 5 months is in itself unusual, as Krassnig has shown that a purulent exudate is present in the middle ear cavities in 80 per cent of all infants examined post mortem, irrespective of the cause of death. Two other paths of infection are considered: (1) that from the meninges either along the acoustic nerve or by the aqueduct of the cochlea, and (2) that of the blood stream. This case may be regarded as one of meningitic neurolabyrinthitis; the meninges were probably involved by an infection conveyed in the blood stream from the primary focus in the chest. Probably the condition is more common than is generally thought, but the difficulty in obtaining specimens prevents its recognition.

EDITOR'S ABSTRACT.

HEREDITARY TRANSMISSION OF DEAF-MUTISM. S. KOMPANEJETZ, Monatschr. f. Ohrenh. **69**:471 (April) 1935.

Kompanejetz classifies congenital deaf-mutism into the following forms: (1) sporadic deaf-mutism, (2) endemic deaf-mutism (in cretins), (3) hereditary hardness of hearing as the result of disease of the internal ear, (4) deaf-mutism as the result of deafness that developed in the uterus and (5) deaf-mutism that developed as the result of trauma during the process of birth. He investigated the form mentioned under (1) which, in contradistinction to the form that develops in cretins, he designated as constitutional sporadic. He studied the hereditary transmission of this form by investigating the genealogical trees of several families in which deaf-mutism occurred. He illustrates these genealogical trees and reaches the following conclusions: 1. The transmission of constitutional sporadic deaf-mutism is manomeric-recessive. 2. The transmission of labyrinthine hardness of hearing can be dominant as well as recessive. 3. It is probable that these two forms differ only quantitatively, not qualitatively. From the eugenic point of view, it is advisable to discourage marriages between persons with constitutional deaf-

mutism because such unions result in the birth of totally deaf offspring. Marriages between a heterozygote with hereditary deafness and a normal person result in apparently healthy children who are likewise heterozygotes and transmit the deafness to their own offspring. Marriages between two heterozygotes with hereditary deaf-mutism result in deaf-mutism of one fourth of the offspring.

EDITOR'S ABSTRACT.

STROKE OF LIGHTNING AS CAUSE OF RUPTURE OF TYMPANIC MEMBRANE. M. MILOVANOVIĆ, Monatschr. f. Ohrenh. **69**:489 (April) 1935.

Milovanović describes necroptic observations on the tympanic membranes of two persons who were killed by lightning. In the first person the left tympanic membrane was intact, while the right had a tear that was 3 mm. in length. In the second person the right tympanic membrane had two ruptures. All four tympanic membranes, the ruptured as well as the unruptured, were subjected to histologic examination, as were also the linings of the auditory meatuses. The microscopic inspection disclosed none of the characteristic changes that were observed on the cutaneous areas hit by lightning. In discussing the cause of the rupture of the tympanic membranes in persons who have been killed by lightning, the author considers three possibilities: the fall on the head, the electrical discharge and the severe air pressure resulting from the stroke of lightning. Regarding the first possibility he says that there were no fractures or fissures at the base of the brain, in the temporal bones or in the osseous frame of the tympanic membrane. Moreover, the soft parts of the head were free from lesions traceable to the fall on the head. The assumption that the electric discharge caused the rupture of the tympanic membranes is likewise improbable, for not only were the tissue changes absent that were present in the regions of the skin which had been injured by lightning, but the hairs in the external auditory meatus were not burned or singed as was the case with parts of the hair of the head. On the basis of the direction of the stroke of lightning, the author is inclined to believe that the intense air pressure caused the rupture of the right tympanic membrane in both cases.

EDITOR'S ABSTRACT.

SYMPTOMATOLOGY AND CLINICAL ASPECTS OF OTITIS CAUSED BY FRIEDLÄNDER'S BACILLUS. F. ALTMANN, Monatschr. f. Ohrenh. **69**:513 (May) 1935.

Altmann points out that the reports of a number of investigators indicate that there is a connection between the clinical course of acute otitis and the type of micro-organism that is causal. Comparisons have been made between the otitides that are caused by noncapsulated and those that are caused by capsulated bacilli. Among the latter group, those caused by Streptococcus mucosus were given especial attention because of their relative frequency. However, later studies disclosed that the dependence of the clinical course on the type of the causal organism is not so great as was at first believed. A number of otitides were observed which had been caused by noncapsulated bacilli, such as hemolytic streptococci, but which took nevertheless a clinical course much like that observed in cases of infection with Str. mucosus, whereas Str. mucosus quite often caused otitis that took an ordinary course. To be sure, Wirth, who gave this problem his particular attention, found that 60 per cent of the otitides that are caused by Str. mucosus take the characteristic protracted course, whereas only 10 per cent of those caused by the ordinary streptococci do. According to recent bacteriologic studies, Str. mucosus is practically identical with Pneumococcus type III. In cases of infection with the other types of pneumococci (I, II and IV), however, the protracted course is comparatively rare. Reports in the literature indicate that there is considerable similarity between the course of the otitis caused by Str. mucosus and that of the otitis caused by capsulated bacilli of the Friedländer group; the latter, to be sure, is much less frequent. The small number of cases that had been reported and the fact that some authors stressed the great danger involved in this form

of otitis induced Altmann to describe the cases that were observed in his clinic. He reports seven cases, in five of which the treatment was surgical and in two of which the condition healed spontaneously. In four cases the onset was insidious, without the characteristic clinical symptoms, the only signs being mild piercing pains in the ears, which disappeared again, and a reduction in the hearing capacity or tinnitus aurium. In three cases the onset was more acute. A paracentesis was never necessary. With the exception of one case, the disorder always took an extremely protracted course. The onset was always followed by a comparatively long period of latency, during which only the impaired hearing capacity and the tinnitus aurium indicated the existence of a disorder. In some of the cases which terminated in spontaneous cure, the period of latency was followed by cure, while in the others signs of mastoiditis appeared. The indications for the surgical opening of the mastoid process were: in three cases, the appearance of a periosteal abscess; in one case, the painfulness of the mastoid process on pressure, the lowering of the posterior upper wall of the auditory meatus, profuse suppurating secretion, subfebrile temperatures and positive roentgenologic aspects, and in another case, slight painfulness of the mastoid process on pressure, lowering of the posterior upper wall of the auditory meatus, profuse suppurating secretion, occasional knocking in the ear and an increase in temperature. In these otitides caused by the Friedländer bacillus the cells of the mastoid process contained the peculiar whitish granulations that are characteristic for the otitides caused by Str. mucosus. Of the cases in which surgical treatment became necessary, only one presented an uncomplicated mastoiditis, while in the other four complications existed. One case terminated fatally, but the fatal outcome cannot be ascribed to the type of infection. Altmann agrees with Eigler, who maintained that the majority of otitides that are caused by the Friedländer bacillus are of rhinogenic origin and develop by way of the eustachian tube. In four of six patients who were examined for it, atrophic change of the mucous membrane of the nasopharynx could be detected. The author emphasizes that many underestimate the possibility of a spontaneous cure in otitis caused by the Friedländer bacillus. He says that Wirth observed three spontaneous cures and that he observed two. EDITOR'S ABSTRACT.

NEW HEARING PHENOMENON. H. ADLER, Monatschr. f. Ohrenh. **69**:538 (May) 1935.

Adler calls attention to the fact that blind persons frequently make objections to the wearing of dark glasses that may be recommended for cosmetic reasons by asserting that their acoustic orientation is impaired by the wearing of glasses. Moreover, persons who are not blind but who wear glasses remove them instinctively if, in extremely noisy surroundings, they wish to follow a conversation or if they wish to hear distant sounds. In order to explain this peculiar behavior of persons who wear glasses the author made a number of tests. In summarizing his observations he states: 1. Acoustic screening-off of parts of the cranium, even if these parts are only small, produces a change in the character of a tone by excluding some of the higher partial tones (real phenomenon). 2. If musical perception is poor, or if the source of sound is deficient in higher overtones, this phenomenon is experienced as a lowering of the tone (virtual phenomenon). 3. The real phenomenon mentioned under point 1 is an acoustic manifestation that can be proved also with physiologic or objective methods. 4. The cranium has a reduced capacity for conduction of tones with comparatively high frequency. 5. Under certain conditions aerocranial conduction seems to play a part in the acoustic orientation in space. EDITOR'S ABSTRACT.

Pharynx

MALIGNANT DISEASE OF THE LARYNX AND PHARYNX. R. STEWART HARRISON and R. SARASIN, J. Laryng. & Otol. **50**:233 (April) 1935.

Harrison and Sarasin describe the technic of the protracted fractional roentgen treatment as practiced at the present moment. The reactions of the various

tissues are discussed. The skin reaction is not a limiting factor, nor is it an indicator for treatment. The skin reaction is reduced or prevented by the application of red and infra-red rays. The reactions of the blood, salivary glands, blood vessels, nerves and muscles are rarely decisive factors in the treatment. The reaction of the mucous membrane is important as an indicator and, in view of the effect on the general condition, the reaction of the substrate tissues is of supreme importance. Damage to the substrate, either by the tumor or by the treatment, leads to a reduction in the relative sensitivity of the tumor. Infiltrating and infected tumors, recurrences, and incompletely treated tumors begin with a damaged substrate and are resistant to treatment. The technic must be modified in accordance with the relative sensitivity of each tumor. The more resistant a tumor the slower is the reaction to radiation and the longer must treatment be continued. This time factor may vary from twenty to one hundred days. The size of the fractional dose and that of the total dose are dependent on this factor. The time factor must also be adjusted to avoid the possibility of further damage to the substrate and further reduction in the relative sensitivity of the tumor. It will therefore be subjected to modifications from day to day in the course of treatment according to the reactions, local and general, presented by the patient. A long time factor and large fields demand slight local reactions, therefore small individual doses. At the same time the intensity of the irradiation epithelitis is reduced, preserving the general condition. It is not yet possible to dispense with the irradiation epithelitis as an indicator. The subjective and objective effects of the irradiation epithelitis are greatly relieved by the use of ultrashort wave therapy. Only when the treatment is exactly suited to the substrate and the tumor will this form of treatment be relatively safe and attended by encouraging results.

EDITOR'S ABSTRACT.

THERAPEUTIC METHODS IN PALATOPHARYNGEAL ADHESION. L. PESTI, Monatschr. f. Ohrenh. **69**:330 (March) 1935.

Pesti shows that the cicatricial adhesion of the soft palate and uvula to the posterior or lateral pharyngeal wall, that is, the palatopharyngeal synechia, is the cause of many annoying symptoms, such as inability to blow the nose, closure of the eustachian tubes and dulness of the olfactory and gustatory senses. After mentioning the factors that may produce this disorder (scleroma, variola, caustics, traumas, inefficient adenotomies or tonsillectomies; also diphtheria, pemphigus, lupus and syphilis) the author gives his attention to the various methods that have been suggested for its treatment. He first mentions the expansion and traction methods, which have the disadvantage that they do not produce permanent results. Then he discusses the use of obturators, which likewise has disadvantages. In evaluating dilation by means of instruments he shows that pernasal dilators are best. The main portion of this report is concerned with plastic methods that aim at a detachment of the adhesion and at covering the wound surfaces which develop following the eventual extirpation of the cicatricial tissue with normal mucous membrane so as to prevent the renewed development of adhesions. These plastic operations utilize partly the preserved uvula or the flaps that are obtained by the frontal splitting of the uvula and the velum palatinum or else the flaps that are obtained from the buccal mucous membrane. After mentioning several other plastic methods the author describes a procedure that was employed by Wein. The latter began his intervention with Schloffer's operation (temporary flapping-open of the nose) and covered the wound surface of the soft palate and of the posterior pharyngeal wall with flaps which he cut from the mucous membrane of the septum. The postoperative dilation was done with a peritoneal forceps. Except for the employment of Schloffer's operation and for certain aspects of the flap arrangement, Pesti considers this method quite satisfactory. He points out that whereas in Wein's case, in which the nose had been destroyed, Schloffer's operation was justified, he himself employs that endonasal procedure. He also gives the reasons for and the manner of his modification of Wein's flap arrangement and

describes two cases and illustrates the "embracing crossing" of the flaps. He asserts that his method produces good functional results.

EDITOR'S ABSTRACT.

TONSILLECTOMY IN THE PRESENCE OF ACUTE INFECTION. F. ZÖLLNER, München. med. Wchnschr. **81**:634 (April 27) 1934.

Interest has been renewed in the danger of tonsillectomy for peritonsillar abscess in the acute inflammatory stage. Several authors consider the so-called abscess tonsillectomy without danger and strongly recommend it. Four cases have been reported in the literature in which serious complications followed tonsillectomy for peritonsillar abscess in the acute stage. Zöllner observed ninety patients on whom tonsillectomy for peritonsillar abscess had been performed. One patient had a chill and a rise in temperature to 40.5 C. (104.9 F.) eight hours after the operation. Another patient had a phlegmonous infiltration of the base of the tongue. In comparing the patients on whom tonsillectomy had been performed with those who had had simple incision of the abscess, Zöllner noted an immediate postoperative drop in temperature more often in those who had had the simple incision and febrile episodes more often in those subjected to tonsillectomy. Zöllner recommends simple incision in early peritonsillar abscess and in cases in which the abscess is well walled off. He advises tonsillectomy when there are signs of sepsis, when pus is not obtained after incision and when fever persists following simple incision.

BRAHDY, Mount Vernon, N. Y. [AM. J. DIS. CHILD.]

Nose

THE REPEATED COLD. CHARLES GILMORE KERLEY, Arch. Pediat. **51**:254 (April) 1934.

The hidden structures of the upper respiratory system, the sinuses, have been shown to be the source of many of the "common colds." In view of this, one case is reported. A child 2 years and 7 months of age, presenting symptoms of anorexia, pains in the muscles, persistent cough and nasal discharge for a period of eighteen months, interspersed with attacks of acute "cold" and slight elevation of temperature, was found clinically and roentgenographically to have extensive infection of the antrums. With clearing up of this involvement the symptoms promptly vanished.

WADDELL JR., University, Va. [AM. J. DIS. CHILD.]

MALIGNANT TUMOURS OF THE NASAL MUCOSA. L. W. PRICE, J. Laryng. & Otol. **50**:153 (March) 1935.

Price shows that a wide range of malignant epithelial tumors arise in the mucosa of the nasal fossae and nasal accessory sinuses, corresponding to the diverse morphology of the normal epithelium of this region. He describes a series of cases, and he concludes that malignant tumors of this region possess highly lethal properties, for which he advances anatomic reasons. He further discusses the recognized difficulty of clinical diagnosis of nasal tumors and advances a plea for early cytologic examination of aspirated fluid. Then he considers the symptomatology of nasal tumors, and stresses the frequency of extranasal symptoms in the absence of specific localizing signs. The pathologic characters of nasal tumors are described, and a simple classification is suggested according to the nature of the epithelium in which they arise. Consideration is given to the occasional occurrence of sarcomas and endotheliomas. The invasion of the nasal fossae and nasal accessory sinuses by tumors of extranasal origin is discussed, and it is concluded that this region is invaded not uncommonly by tumors arising in the following situations: (1) epithelium of dentigerous origin; (2) glandular epithelium; (3) squamous epithelium of the palate and alveolar margin. The complexity of tumors arising from paradental epithelium is shown to be attributable to their origin from specific or multipotential cells derived from the "anlage" of the enamel organ.

EDITOR'S ABSTRACT.

MAXILLARY SINUSITIS: A STATISTICAL INVESTIGATION. I. B. THORBURN and L. L. RATAZZI, J. Laryng. & Otol. **50**:185 (March) 1935.

Thorburn and Ratazzi review a series of 508 cases of maxillary sinusitis, 328 chronic and 180 acute. The results of treatment are summarized in the form of a block graph. Six patients died, a mortality of 1.18 per cent; there was an operative mortality of 1.6 per cent. In nearly all acute cases and, with certain exceptions, in chronic cases, when conservative treatment fails, preference should be given in the first place to the intranasal rather than to the radical operation. The presence of nasal polyps adversely influences the chance of cure.

EDITOR'S ABSTRACT.

CHANGES IN THE PAPILLA OF NASAL ORIGIN. BONNET, SARGNON and PAUFIQUE, Bull. Soc. d'opht. de Paris, June 1934, p. 349.

A boy 13 years old, complained that with his right eye he had been seeing many black spots in his field of vision for the past eighteen days. Visual acuity was normal. The anterior segment and vitreous were normal. The papilla presented a hazy outline, the veins were dilated, and one could observe a circle of edema adjoining the disk on the nasal side. The temporal segment was normal. The visual fields had the usual extent, but there was some constriction for colors, more especially for green. The x-ray photograph of the head, the urine and the Wassermann test were normal. The right nasal passage showed signs of obstruction. The edema of the fundus increased. Several polyps were removed from the nose, and recovery was immediate.

L. L. MAYER. [ARCH. OPHTH.]

RETROBULBAR NEURITIS—SINUSITIS—MULTIPLE SCLEROSIS. G. WEILL and J. NORDMANN, Rev. d'oto-neuro-opht. **12**:496 (July-Aug.) 1934.

Among the medical problems solution of which depends on the collaboration of neurologists, ophthalmologists and rhinologists is the problem of acute retrobulbar neuritis. A large number of patients who recover spontaneously are later found to have multiple sclerosis. An increasing number of patients with bilateral subacute retrobulbar neuritis (atypical cases) have later manifested multiple sclerosis in spite of early operation on the posterior sinuses.

Two cases are reported, in both of which multiple sclerosis became manifest three and six years, respectively, after apparent recovery. Both patients had suppurating sinuses which were operated on. Atypical retrobulbar neuritis is attributable in general to disease of the chiasmal region or of the posterior sinuses. Behr produced in rabbits signs of multiple sclerosis by transplanting mucosa from the sinuses into the cranial cavity. At least in some cases of multiple sclerosis and retrobulbar neuritis, the bucconasal route of infection must be assumed. "Interventionists" should review their old case histories to determine the number of cases in which multiple sclerosis has developed and compare their findings with the statistics in cases in which operation was not performed. If the incidence of multiple sclerosis in such cases is really rarer after curettage of the sinuses, Weill and Nordmann will join the ranks of interventionists in order to try to prevent the onset of multiple sclerosis. Spontaneous recovery nearly always takes place in cases of retrobulbar neuritis.

DENNIS, Colorado Springs, Colo. [ARCH. NEUROL. & PSYCHIAT.]

RESULTS OF RESEARCH ON RHINOSCLEROMA IN VOLHYNIA. W. G. DROBOTJKO, S. N. RUČKOWSKY, S. S. DJAČENKO and A. Z. KORŽINSKY, Monatschr. f. Ohrenh. **69**:322 (March) 1935.

Drobotjko and his associates point out that according to recent literature rhinoscleroma is comparatively frequent in Volhynia, in other parts of the Ukraine and in the U. S. S. R. However, in spite of the many newly discovered cases they are unable to say whether, as some have asserted, the incidence has increased

since the war. They consider it possible that the increased incidence is only apparent in that, as the result of improved clinical and laboratory methods, the number of cases detected is larger. Nevertheless, they concede that rhinoscleroma presents a grave problem in these regions, the more so since the etiology and the epidemiology have not been fully explained as yet. They report the results of studies which they carried out in four villages. They examined the nasal and nasopharyngeal mucus for the presence of capsulated microbes, and they also tried to make the complement-fixation test according to Bordet and Gengou, with antigen from capsulated organisms, but the latter procedure had to be abandoned. They found that the flora of capsulated micro-organisms is rather manifold in patients with rhinoscleroma as well as in those with ozena. They give a tabular report that indicates the individual characteristics of the various types of capsulated bacilli. They observed Frisch's bacillus (Bacterium rhinoscleromatis) in a comparatively small number of cases of rhinoscleroma, but they think that repeated tests might have disclosed it in a number of cases in which the first test had been negative. But even if they cannot bring definite proof of the etiologic significance of this bacillus, they concede that they found a large number of capsulated bacilli in the nasal secretions of patients with ozena, and they think that this indicates that capsulated bacilli thrive in the pathologically altered mucous membrane of these patients. Studies on children with various pathologic conditions of the nasopharynx indicated the same. In regard to the contagiousness of rhinoscleroma the authors say that they generally found only one case in a family; thus their studies do not corroborate the assertion of Elbert, Gerkess and Feldmann, who maintained that they frequently found familial foci. Other observers, however, have stated that familial occurrence of rhinoscleroma is rare, and the authors are inclined to agree with them. The authors were unable to detect a connection between hygienic conditions and the incidence of rhinoscleroma. They found cases of rhinoscleroma among those who lived under hygienic conditions as well as among those who did not, and they observed it among the well-to-do as well as among the poor. Occupation likewise seemed to have no influence on the incidence of the disorder.

EDITOR'S ABSTRACT.

Miscellaneous

PRIMARY MELANOTIC SARCOMA OF THE ESOPHAGUS. T. C. JALESKI and P. V. WALDO, Am. J. Cancer **24**:340, 1935.

A case of melanotic sarcoma of the esophagus is described in a man of 69. The postmortem examination showed a primary pigmented tumor of the esophagus with metastases to the lungs, liver, pancreas and spine. The presence of melanin in the tumor cells was proved by the use of silver, iron and fat stains, as well as by treatment of the tumor tissue with hydrogen dioxide, acids and alkalis.

FROM THE AUTHORS' SUMMARY. [ARCH. PATH.]

HYPERTENSIVE MENINGITIS OF RHINOLOGISTS AND SEROUS MENINGITIS AND ARACHNOIDITIS OF NEUROLOGISTS. J. RAMADIER, Rev. d'oto-neuro-opht. **12**:491 (July-Aug.) 1934.

Ramadier questions the identity of the pathologic processes in cases of serous meningitis, familiar to neurologists, and in cases of otogenous hypertensive meningitis. While otogenous meningeal hydrops presents itself as an episodic physiologic disturbance of sudden onset but brief duration, and most often as a single attack, the serous meningitis of neurologists appears as a meningeal or, more probably, as an encephalomeningeal condition, slowly progressive and subject to evolutive exacerbations. Again, differences are observed in comparing the cystic arachnoiditis of neurosurgeons with the endocranial syndrome observed by otologists accompanying an otitis or following a radical operation on the mastoid. In the latter process the phenomena appear more or less rapidly, with signs referable to the

cerebellum or to the labyrinth, and when the dura is incised cerebrospinal fluid spurts out and the patient is miraculously cured. On the contrary, posterior cystic arachnoiditis often presents a perfect picture of tumor of the cerebellopontile angle; an extensive operation (as for tumor) is required, and adhesions must be broken. The process is prone to return as a result of the formation of new adhesions.

The clinical report of Moulonguet and Anglade, "Hypertensive Syndrome of the Posterior Cerebellar Fossa Mistaken for Cerebellar Abscess" *(Rev. d'oto-neuro-opht.* **12**:513, 1934), presents a perfect example of otogenous meningeal hydrops.

DENNIS, Colorado Springs, Colo. [ARCH. NEUROL. & PSYCHIAT.]

HYPNOTHERAPY OF SPEECH DISORDERS. F. VÖLGYESI, Monatschr. f. Ohrenh. **69**:339 (March) 1935.

After pointing out that speech disturbances are quite amenable to hypnotherapy and after showing that hypnotherapy provides a better insight into the highest spheres of the human central nervous system, Völgyesi points out that the cerebral centers which coordinate the speech function have in the course of phylogenetic development been superimposed one over another. He considers hypnotism as the vasomotor exclusion of the various brain centers that in the course of the phylogenetic development have become superimposed one over another. This exclusion begins with the frontal spheres (logical spheres) and can be brought down to the deeper regions of the cerebral scale, in extreme cases even to the life centers of the medulla oblongata. In the psychotherapy of the cerebral disturbances the determination of the cerebral center of the disorder is of vital importance. The author emphasizes that the cerebral centers that have connection with the speech function can be found in all ranges of the cerebral scale. In the course of the phylogenetic development more differentiated voice and speech organs have been superimposed on the elementary apparatus in the primitive brain. Whereas until recently the island of Reil and Broca's area were considered the cerebral centers of speech, it is now understood that the speech mechanism is much more complicated. The author points out that there are speech disturbances that yield to simple pedagogic measures, that in other cases hypnotherapy is a valuable adjuvant and that in still others hypnotherapy is the only method that is effective. He emphasizes that whereas the impairments of the primitive brain are incurable, the injuries of higher, newer centers can frequently be compensated for by new learning. The deeper the disorder is localized in the cerebral scale the more unfavorable is the prognosis. The author further discusses the value of hypnotherapy in the various speech disturbances. First he gives his attention to stuttering. He maintains that as a rule it can be decided after a few sessions whether the treatment will be effective or not. He warns against routinism and against all extremes and emphasizes that the somatic as well as the psychic factors must be considered. Moreover, he thinks that in addition to hypnotherapy other promising methods should be employed. In speech disturbances that were caused by hemiplegias, thromboses and embolisms, he obtained favorable results with hypnotherapy provided that (1) the impaired centers were localized in the neopallium and not in the regions of the primitive brain and that (2) the paralysis had not persisted for more than a year. He points out further that even if the speech disturbance is organic, psychic factors are usually also involved. With the slightest psychic disturbance, disorders in the cerebral nervous system become at once manifest in the speech mechanism. The physician employing hypnotism can, by excluding the confused associative mechanism of the patient, communicate his suggestions almost directly to the thalamus, into the extrapyramidal, that is, the subconscious centers. In the last part of his discussion the author emphasizes the necessity of close cooperation between the neurologist and the psychologist, which he expresses in the slogan "First neurology and then psychology and no psychology without neurology."

EDITOR'S ABSTRACT.

VARIOUS TYPES OF ILLUMINATION IN BRONCHO-ESOPHAGOSCOPY. E. I. MATIS, Monatschr. f. Ohrenh. **69**:409 (April) 1935.

Matis is of the opinion that if the advantages of distal and proximal illumination are compared, it becomes evident that the two methods are complementary: Proximal illumination gives a good general view, and distal illumination makes possible a careful inspection of certain sites. For this reason the author considers it advantageous to combine the two methods of illumination in the same instrument. He describes devices for distal illumination that can be added to instruments equipped for proximal illumination and then enumerates the advantages of the broncho-esophagoscope that is equipped with these devices.

EDITOR'S ABSTRACT.

Society Transactions

AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY

Forty-First Annual Meeting, Toronto, Canada, June 3-5, 1935

E. W. HAGENS, M.D., *Chicago, Abstract Editor*

PERRY G. GOLDSMITH, M.D., TORONTO, CANADA, *President*

Monday Morning, June 3, 1935

The first scientific session of the forty-first annual meeting of the American Laryngological, Rhinological and Otological Society convened in the Royal York Hotel, Toronto, Canada, with Dr. Burt R. Shurly, of Detroit, former president of the society, presiding.

CHAIRMAN SHURLY: The President is delayed and has asked me to start the meeting.

The first order is the presentation of cases. Are there any? Apparently there is none.

Next is the exhibition of instruments and apparatus. Since there is none, that is dispensed with.

The next order is the formal program, which awaits the return of the President. The reader of the first paper, our guest of honor, has not entered the room as yet.

[A brief recess was taken.]

CHAIRMAN SHURLY: The first paper on the program is that of our distinguished guest who comes from England. I have the honor and privilege of introducing to you Mr. Norman Patterson, of London.

TREATMENT OF CARCINOMA OF THE NOSE, NASAL SINUSES, MOUTH AND BUCCOPHARYNX, WITH SOME REMARKS ON DIAGNOSIS. NORMAN PATTERSON, F.R.C.S., London, England.

A tumor in the nasal field starts in one area but invades other regions by extension. A well advanced tumor is usually easily diagnosed, but at an early stage the lack of characteristic symptoms may make the diagnosis difficult. As a rule, there are no metastases in the neck until late in the disease. Generally speaking, a tumor growing in the lower part of the nasal chambers is more amenable to treatment than one originating in the upper portions. The surgical approach is discussed; in some cases the external incision is advisable; in others removal of the hard palate provides the pathway. Diathermy is always used freely when dealing with the soft parts. Preliminary ligation of the external carotid artery has not seemed necessary. Radium and x-ray are used in combination with electrosurgery but never alone unless the tumor is too far advanced for operative treatment.

In carcinoma of the nasopharynx surgical intervention is not worthy of serious consideration, and some form of radiation holds out the only hope. Carcinoma of the buccopharynx is often associated with metastases in the cervical glands before the primary focus is discovered. Eradication of the glands in the neck is generally more difficult than destruction of the primary tumor. A carcinoma of the posterior third of the tongue is particularly liable to have early and extensive metastases. The surgical attack on the glands in the neck precedes the treatment of the primary tumor. Diathermy is much better than radium in these cases. Radium is used, however, in conjunction with surgical procedures, especially in

advanced cases. In excision by diathermy the external carotid artery or the lingual artery may be ligated.

It is questionable whether a growth situated on the posterior pharyngeal wall should be treated with diathermy, as osteomyelitis of the cervical vertebrae is likely to follow.

Carcinoma of the hypopharynx, involving the base of the tongue, epiglottis, pyriform sinus, etc., is also discussed. In many of the cases lateral pharyngotomy (Trotter) is the proper surgical approach. In advanced cases irradiation of the growth is advised.

DISCUSSION

Dr. Gordon B. New, Rochester, Minn.: All will agree that during the last decade or two there has been marked evolution in the treatment of malignant conditions of the types under discussion. This is well brought out by the treatment of the malignant tumors of the antrum which Mr. Patterson discussed. Years ago these were all taken care of by resection, with small operative risk and small mortality, and few of the patients stayed well. Now patients taken care of with diathermy and radium stay well over a long period of time.

The growth in the upper jaw rarely metastasizes. Practically all low grade tumors that extend to the cheek metastasize at that time the same as any other type of malignant growth.

Mr. Patterson brought out the classification in relation to the ethmoidal tumors occurring mesially or posteriorly, and the location is important, along with the type of growth, in determining whether the patient is going to get well. One cannot compare growth in the alveolar process with growth higher in the antrum, particularly that situated in the region of the ethmoid. That is a highly malignant region.

I feel that in the low grade carcinomas cauterization and diathermy give much better results than any type of radiation. The surgical removal of the growth in the cheek gives many possibilities so far as cures are concerned. However, in this group of cases, in which the operation consists in removing the submaxillary glands, ligating the lingual vessel and excising the lesion of the cheek by diathermy, there is a possibility of getting into the submaxillary gland that is involved, and going ahead and doing the operation on the cheek would rather muss that up.

In lesions of the tongue, I feel that radiation (especially in the highly malignant tumors) gives the best results. In the low grade lesions the cautery, excision and diathermy offer the patient a good chance of getting well.

I want to mention one point in regard to lesions at the base of the tongue, just over the base of the tongue and involving the epiglottis. The highly malignant ones primarily involve the tongue and a section of the epiglottis. Doing the usual tracheotomy one can destroy the lesion with surgical diathermy and insert radium seeds directly into the wound.

A month or two ago in such a case I removed the hyoid bone and sequestrum from the inside, which shows to what extent the lesion can be removed in this rather conservative way.

Dr. Henry B. Orton, Newark, N. J.: Surgical operation, diathermy and treatment with x-rays of high voltage, in combination, constitute the procedure of choice in attacking these tumors. The block resection of one or both sides of the neck, with ligation of the external carotid artery and resection of the jugular vein, is a most important step in eradicating this disease.

Even in some of the cases of carcinoma of the lip, the lower lip, in which the carcinoma has been removed and no palpable glands encountered at the time of the operation, I have found, six months or a year following, that the glands in the upper part of the neck were involved. Since then in such cases I have been removing the carcinoma and blocking the section of the upper part of the lip.

Another important point in all Mr. Patterson's procedures is a very, very good exposure. He did not take up the lower pharyngeal carcinoma, but the same point holds good for that, namely, the good exposure in which to attack.

DR. DOUGLAS QUICK, New York: One recognizes in Mr. Patterson's paper the words of a master. As regards radiation therapy, one must remember that it calls for technical facility, accuracy and experience. There is something peculiar, and thus far unexplained, in the unusual radiosensitivity of hypopharyngeal epidermoid carcinoma as compared with a tumor of comparable histologic grade in the oral cavity proper. Biopsy is always done after external irradiation of the carcinoma is under way. Implantation of gold radon seeds in the tumor also follows external irradiation. Surgical diathermy is used in the mouth, following external irradiation, for access and drainage, for infection, for tumor invasion of bone and for cleaning up bulky, infected, fungating tumor tissue in soft parts.

Laryngectomy for carcinoma of the larynx is now obsolete, and this will be recognized generally within the next ten years or less. I am an advocate of conservative treatment of the areas of lymph node drainage of the neck rather than of routine block dissection, on the theory that up to a certain point, at least, the nodes perform a conservative and defensive function. Usually surgical exposure and implantation of radon seeds are carried out. Of course, preliminary external irradiation of the area precedes this.

When a radiologist speaks before an audience, and particularly an audience of surgical workers, he is expected to speak in terms of percentages of cures at the end of any given period, but when he listens to a paper by a distinguished surgeon he usually goes away with the impression that he has heard described a series of beautifully planned surgical operations, the percentage of cures from which was left in doubt.

I should have been delighted if Mr. Patterson had given a basis on which a comparison could be made between the results being obtained by surgical treatment in such cases and those which may be obtained by radiologic methods, and there is no thought, wish or desire to place the two in competition with each other.

Radiologists feel that in the advances of the last few years (especially the last five years) they have made an enormous contribution to the treatment of malignant diseases of the nose, mouth and throat. The claim which they make, and on the basis of which they believe they are entitled to consideration, is that when radiologic methods are successful they are accompanied by a degree of conservation of tissue which is out of all proportion to anything that surgical methods can show, and unless radical surgical operations are done, they can point at the end of any given period to a higher number of cured patients, and then they submit that the radiologic methods are superior.

Another thing to be observed is that frequently in discussions of this sort, when statistics are quoted, the best statistics that are produced in the world are quoted. I decided to be modest—possibly you would think it was the opposite—and state only what my associates and I are accomplishing in our work as a basis of comparison.

In the treatment of carcinoma of the tongue we have had a series of results that are somewhat surprising to me inasmuch as there has been a tremendous variation in the curability of lesions by radium alone depending on their situation on the tongue, and I will show you a slide in a few minutes that illustrates this.

(Slide is shown.) We have had the highest percentage of cures in carcinoma involving the base of the tongue, namely, 66 per cent. The figures that follow are based on a study of patients treated during the years 1928-1929-1930: base of the tongue, 66 per cent; lateral margin, 24 per cent; tip of the tongue, 33 per cent; dorsum, none. That is by radiologic methods only.

In the dorsum of the tongue, in addition to the radiologic treatments applied, diathermy and radical surgical operation have not improved results.

In diseases of the tonsil we are in the favorable position of frequently having to deal with transitional carcinoma, which is relatively radiosensitive, and have reached the general opinion that if in cases of this type treatment is begun prior to the stage of glandular involvement cures will be obtained in a high percentage by external irradiation in the form of high voltage x-rays or teleradium alone. However, this does not represent a cross-section of the problem.

Taking all the patients together, we have been able to have 35 per cent free from disease at the end of the five year period. In some of these, block resections have been done.

In this country the radiologist who has the courage to produce the reactions which are called for frequently finds himself in trouble because of the legal consequences of producing reactions which the laity and some members of the medical profession label "burns," and we dare not produce quite the type of reaction that Coutard does in France. However that may be, radiologic treatment has resulted in a very substantial improvement.

MR. NORMAN PATTERSON, London, England: With regard to Dr. Gordon New's remarks, I practically agree with everything he said, and the same applies to those of Dr. Orton.

It is a much more difficult matter when it comes to a question between the surgeon and the radiologist. I am all for the radiologist. I think the radiologists are doing a magnificent work, and I hope that in the future, although the cases, I imagine, will not be turned over entirely to them, the combination of radiology and surgery will give much better results than have been obtained in the past.

I have not had time to refer elsewhere to matters that I have here in the table. I consider that 35 per cent cures in the cases of tonsillar cancer is extremely good, better than mine, but I hope that with the combination of diathermy and radiation one will get something better than 35 per cent.

The best results I have had so far are with carcinoma of the cheek. I have treated 10 patients, and 8 are alive; 1 is alive for three years, 3 for eight years and 1 for six years.

I was interested to hear Dr. Richards' remarks on carcinoma of the tongue. In my hands it has been very refractory.

I had no time to deal with the pharynx, and laryngopharyngectomy has been far from encouraging. Eventually I think laryngopharyngeal carcinoma will be treated largely by radiologic methods.

THE PROGNOSIS OF MODERATE DEAFNESS IN YOUTH; VARIATIONS IN THE DISEASE, MANAGEMENT AND TREATMENT. DR. E. P. FOWLER, New York.

This is a statistical study of patients seen in the clinic. The cases are divided into four groups of (1) chronic suppurative otitis media, (2) recurrent suppurative otitis media, (3) healed suppurative otitis media and (4) past masked suppurative otitis media. The most important factors in a favorable prognosis are the early detection of the disease of the ear and proper treatment.

DISCUSSION

DR. MAX A. GOLDSTEIN, St. Louis: There is much of careful observation, rational conservatism and common sense in this paper. The reference to the treatment and unnecessary removal of tonsils in this particular type of patient is a pertinent one, and it comes home to me rather seriously in the observation that at the Central Institute, St. Louis, where even a more serious form of hearing defect, congenital deafness, is involved, in my inspection of several hundred patients who come from twenty to twenty-five states I find that congenitally deaf children almost all have had their tonsils removed, and not only the tonsils but in many instances parts of the uvula and so forth, which may interfere with good speech and the proper physiologic function of these parts that are so necessary to speech.

It is rather sad that it is still the practice to remove tonsils, ordinary hypertrophied tonsils, in congenitally deaf children with the thought that it may improve the hearing.

A clinic for the prevention of deafness like that conducted by Dr. Fowler is one of the newer developments in the consideration of the hard of hearing child, but it has not gone far enough. It still has its limitations.

After the otologist has delivered his opinion as to the character of the hearing defects in the many children who come under his observation through tests of

the group on the audiometer, and who are sent to him for further test, inspection and advice, it still remains, after he has given his advice, for the school authorities of that district to help carry it out. If these children show, as Dr. Fowler indicates in his summary, various types and degrees of defective hearing, some definite measure should be undertaken by the school authorities in coping with the matter. This is being agitated; it is in the air; but in most communities the otologists have not quite reached a practical program for the development of this thing.

The hint in Fowler's classification that otosclerosis should be considered from the point of view of age has its limitations.

About ten years ago Alexander reported a case of clinically diagnosed otosclerosis in a girl of 12. A few years later he saw the temporal bones and substantiated the diagnosis under the microscope.

A few years ago Stacy Guild at Baltimore, at the otologic laboratory of Johns Hopkins Hospital, found accidentally, without having a record of the clinical character of the case, typical otosclerosis in a child of 2.

I have now under observation an apparently congenitally deaf child. When she was first examined three years ago, she was 3 years old. On digging into the family history five generations in a line were found in which about nineteen members had otosclerosis.

Now what is this child? Is she congenitally deaf, or has the otosclerotic process developed as a hereditary condition or at birth? If you can find otosclerosis in a child of 12 and a baby of 2, why not inherited otosclerosis and otosclerosis at birth? It is a possibility. It ought to be thought of.

There is always a passing smile when one speaks of otitis media catarrhalis chronica in 1935. I agree with Dr. Fowler. I do not know what it means today and, quoting from his paper, "The loss in hearing in chronic and recurrent groups is proportional to the chronicity and severity of the suppuration, and not only is it dependent on the severity of the suppuration, but on a continuance of the suppuration of rather severe type for a period of years," and there are so many patients with this kind of suppuration that with the constant, persistent irritation by the suppuration and by the mechanical manipulation of treatment, some of those with hereditary tendencies to otosclerosis, may come to have it—otologists have admitted that otosclerosis is about the only thing in their field that is hereditary—such irritations may provoke an active stimulation of the otosclerotic process.

I like the emphasis on the ignoring of slight insignificant deafness in acute cases as a danger signal. I think that is a wise and timely observation.

To revert to the otosclerotic possibilities, for one moment, otologists know that almost any constitutional upheaval will incite an otosclerotic process, and in every pregnant woman who has an otosclerotic background, there is an increase in deafness with the birth of each child.

Why not follow up Fowler's suggestion? With the constant presence of chronic suppuration and irritation by mechanical interference, why not consider this as a possible cause for the development of otosclerosis or the stimulation of an otosclerotic process?

Dr. Gordon Berry, Worcester, Mass.: It has been my privilege to examine some of the material developed by Dr. Ruth Guilder and Miss Louise Hopkins in their careful researches on the deaf pupils at the Clarke School for the Deaf at Northampton, Mass. In a paper read before the eastern section of the society last January we reported that all those children had some hearing, that most of them had a form of deafness involving the nerve and that the average graph showed a descending curve.

Periodic audiometric tests of those children have been made for nearly four years, and the analysis of the results is giving valuable data. We suspect (1) that there is a more rapid recession in hearing in the earlier years of the children at the school, (2) that this recession is intermittent rather than continuous and (3) that it is synchronous with recurring colds. If that is true, the findings are significant from both the medical and the educational points of view. I am hoping

the workers who are carrying on the research will soon have enough data to substantiate this suspicion.

In Worcester, phono-audiometric tests and otologic examinations have been carried on in the public schools for three years. In 12,000 tests, Dr. Harry B. Goodspeed has found an appreciable loss of hearing in 5 per cent. Secondary tests, after the institution of early therapeutic aid, have shown definite gains in the hearing of many. But, on the other hand, a few have shown a gain without having had otologic aid in the interim. This confuses the issue. The cases of nerve deafness do not offer so favorable a prognosis; the hearing acuity has remained approximately stationary during this period.

I learn with interest that so many of Dr. Fowler's children showed a gain in hearing. He does not catheterize. He does not use nasal packs or sprays. He does no operative work on the sinuses. He cautions against wholesale tonsillectomies. These are sound policies. He does an adenotonsillectomy when it is indicated. Care of the general hygiene is observed. Recurring colds and infections of the sinuses are given routine treatment.

Are politzerizations used? How are suppurative ears controlled? If the adenoids alone are removed, is the aftergrowth of pharyngeal and nasopharyngeal lymphoid tissue more or less active than after the removal of both the tonsils and the adenoids? Such are questions which arise but which the shortness of his time did not permit him to elaborate on.

As to whether tonsils furnish autogenous vaccines, in my experience a diseased tonsil may serve as an immunizing agent in a child, but it is very doubtful if it so serves in an adult.

It is significant that the 512 double vibration or conversational range is the one suffering most and that the 8192 double vibration or high range shows the least loss. Of special importance is Dr. Fowler's assertion that early detection of the difficulty gave the best results. This reiterates the claim that routine testing in the school is necessary. Only so can these cases be discovered early. Over and over again those who do group tests discover fairly advanced forms that neither the teachers nor the parents nor the children were aware of. Early detection and conscientious care will lessen or eliminate a considerable proportion of the advanced cases in adult life.

Dr. J. W. Jervey, Greenville, S. C.: I should be the last one to question anything that Dr. Fowler had done, but I am sorry that he grouped his cases of moderate deafness under one head and gave a general summary of the averages as to the outcome of the cases. What I want to get at is that there are so many different causes of deafness, from slight deafness to the entire loss of hearing, that, naturally, on grouping the cases together the average will give a wrong impression as to what might be done in certain classes of cases.

I wish to emphasize that in many cases, even those of more or less advanced type, the cause which might be found in the study of the biochemistry and nutrition must be seriously taken into account in order to arrive at a reasonable prognosis, and I firmly believe that with the further study of this group of cases, which comprises perhaps the largest number of cases of deafness, results will be obtained which heretofore have never been attained, and I hope that more time, more attention and more study are going to be turned to the consideration of nutrition and biochemistry in relieving these conditions. The statistics will then be vastly improved.

Dr. Edmund Prince Fowler, New York: If Dr. Jervey will read the paper he will see that just what I avoided doing was to group all the cases together.

Regarding otosclerosis, Dr. Goldstein brought up the point that these children may have otosclerosis. That is true. In general autopsies at a large hospital, 1 in 20 persons showed otosclerosis whether they showed deafness or not. Many did not show deafness because the otosclerosis did not involve the stapes.

Otosclerotic children have to be excluded in some way. I do not know any other way to exclude them except by providing that they should not have a family

history, which is rather indefinite, because we all inherit our parents' and grandparents' looks, outside and inside. We have the same tendency to certain diseases that they had, irrespective of whether it is otosclerosis or not. The matter may not be traced in a definite genetic way, but certain families seen in practice tend to have certain things. It may be that the infectious element comes in because they live together, but the anatomic background is also there; otherwise they would not have the same faces as their fathers and mothers.

Now, it is difficult in clinics to institute any complicated system of dietetics and biochemistry. It is hard to get any treatment at all. What is the good of a child's coming in once a week for politzerization? Even in private practice, if one has a child come in once or twice a week for catheterization or politzerization, what good is that from a basic standpoint? It is only a drop in the bucket. Something besides that has to be done to get over these things and it has to be done at home.

ANATOMIC ANOMALIES OF IMPORTANCE TO THE OTOLARYNGOLOGIST. DR. OSCAR V. BATSON, Philadelphia.

Of the many anomalies of the vascular system which are of interest to the otolaryngologist some are true anomalies and are not readily forecast. A large group, which may be called pseudo-anomalies, are here shown to be due to pathologic changes in the vascular system. Their presence may be suspected in cases of peripheral arteriosclerosis, especially when it is associated with hypertension. A diagram of the pseudo-anomalous vessels is presented.

DISCUSSION

DR. SAMUEL IGLAUER, Cincinnati: The essayist did not refer to the venous system. However, one should consider the question of the bulb of the jugular vein protruding into the middle ear, a difference in size of the internal jugular veins and a difference in diameter of the sigmoid sinuses. The vena thyreoidea ima, when present and distended, may interfere seriously with tracheotomy.

The essayist has spoken of vascular anomalies which might be termed acquired rather than congenital.

While one is aware that a sclerotic artery is tortuous, as manifested in the temporal region, and that along with gray hairs it is a marker of time, one may not have sufficiently considered that such an artery is necessarily elongated and always increased in diameter.

As to the practical application in performing surgical operations, one should always expect the usual rather than the unusual, and one should not forget that one has an educated finger as well as an educated eye.

In considering the relation of an abnormally placed innominate artery in relation to the trachea, I understood the essayist to say that one might find it in adults but probably seldom in children. Tracheotomy should usually be a deliberate operation, but in those instances in which one has to perform a penknife tracheotomy as an emergency it is better to open the trachea high up, even at the risk of injuring the vocal cords.

A dilated artery in the carotid canal has great significance nowadays when the petrous bone is so frequently invaded.

The other practical application is that in proceeding surgically in any part of the body one must expect the common thing and not look for the anomaly, but it is pointed out by the essayist that, given a patient with signs of arteriosclerosis, this patient may have an anomalous distribution of the main arterial trunks as a result of the arteriosclerosis, and this shows again the intimate relation between internal medicine and specialized medicine, which one too often forgets.

MR. NORMAN PATTERSON, London, England: As far as I can see, one has a choice between the rare vessels in front of the lower part of the innominate artery and the common carotid artery. Any of these vessels might be divided in a tracheotomy that has to be carried out in a hurry.

Then the external carotid artery, passing under these angles of the jaw here, might be in jeopardy in a tonsillectomy or in an operation for a malignant growth in that region.

The relationship of the abnormal internal carotid artery to the sphenoid bone is of interest. With regard to the sphenopalatine vessel, I know of a case—in a friend—in which there was a large hemorrhage on opening the anterior wall of the sphenoid sinus. The patient nearly died.

With regard to the "penknife tracheotomy," in any urgent case it is always advisable to do a laryngotomy, if possible, rather than a tracheotomy, and then one is free from the danger of opening the large vessels.

There is one condition I should like to comment on: the abnormally large mastoid vein. Apparently the mastoid vein may be as large as the internal jugular vein, the venous part going through the cortex and passing down into the external jugular vein.

I have observed a case in which apparently there was no internal jugular vein on one side, simply a vein from the carotid artery. I wonder what would happen if one had to tie the opposite internal jugular vein for infection of a sinus.

Dr. John F. Barnhill, Indianapolis: I wish first to speak of the anomalous division of bifurcation of the carotid arteries. It is usually stated in textbooks that the carotid arteries bifurcate on a level with the superior rim of the thyroid cartilage. Now that is a matter of considerable practical importance, for, as you well begin to know, the laryngologist's work is shifting inevitably into the neck.

It has been my observation that the superior carotid artery bifurcates almost as often above the hyoid bone as it does in the region ordinarily named in the standard textbooks on anatomy, and it is common for the external carotid artery to bifurcate under the angle of the jaw and even higher.

In a recent observation of 23 cadavers 13 had arteries bifurcated above the hyoid bone, and 2, under the angle of the jaw. This would be of tremendous importance to one who was attempting to ligate this vessel.

Speaking of the internal facial artery as it passes through the sphenopalatine canal, I wish to confirm what Dr. Batson has said, that this artery is sometimes of enormous size, and that, more than the arteries one finds almost anywhere else, whether in young persons or in old, it sometimes is enormously curved and kinked, and gives the observer the feeling that he is looking at a worm that has tied itself into a knot just in front of the sphenopalatine ganglion. This is important because of the fact that it is necessary to go farther back than the artery since the artery nearly always lies in front, and it is nearly always larger than one thinks, and it is nearly always curved and knotted in the way I have described.

As a practical thing I wish to speak for a moment of the veins of the neck. Our distinguished guest said, "What would happen if one ligated the internal jugular vein on one side when that on the other was almost absent?" The patient, Doctor, might recover. There are a number of instances in which both jugular veins, as you know, have been ligated, and the patient lived.

Mr. Patterson, London, England: I have seen only 2 cases in which this happened, and in both the patients died.

Dr. Frank Robert Spencer, Boulder, Colo.: I should like to put on record at this time a case in which the external carotid artery was underneath the right tonsil. It was very tortuous and very large. I was able to have a postmortem examination in this case to prove the point.

Dr. Oscar V. Batson, Philadelphia: I should like to point to one place where the anatomist has played us false. He has always described dead arteries and has assumed that they were like live arteries. Just because an artery does not appear in the operative field in the cadaver does not mean that a slight increase in length will not push it into the operative field in the patient.

One may have to revise all one's notions about diameters of vessels because there has been no adequate study of that matter.

Tuesday Morning, June 4, 1935

EARLY AND LATE OPERATION FOR ACUTE SUPPURATION OF THE MIDDLE EAR AND TEMPORAL BONE. DR. V. V. WOOD, St. Louis.

Early operation is contrary to sound surgical principles pertaining to the successful treatment of acute inflammatory processes when the end in view is drainage. Many points are brought out to show that one should not hurry to operate. At present early operation is carried out in cases complicated by meningitis, but in time this may prove to be wrong. In some cases what may seem to be an acute condition is merely the lighting up of an old one, and hence early operation is more justifiable. On the whole, general surgical principles are the best to follow.

DISCUSSION

DR. HAROLD I. LILLIE, Rochester, Minn.: Dr. Wood has presented certain points that are debatable.

Ballance has said that when the pathology of any lesion is well understood there should be no lack of agreement as to the course to pursue in the rational management of it.

Myringotomy is instituted to relieve the pain and afford drainage of the discharge caused by middle ear disease. In secretory otitis media, this operation may be deferred; in suppurative otitis media it should be performed when the diagnosis is made. Myringotomy cannot be expected to prevent surgical mastoid disease in all cases. Myringotomy is preferable to spontaneous rupture because the incision is less liable to be followed by a permanent perforation of the drum.

Infectious processes that involve cavities with rigid walls are quite different pathologically from infectious processes that involve soft tissue structures. The structural differences in temporal bones are clinically and roentgenographically recognizable. Pathologic processes in the various types of structures are quite different. Operation in the coalescent type of mastoiditis, which occurs in well pneumatized mastoid processes, may be more safely deferred than operation in the osteothrombotic type of disease, which most frequently occurs in the diploic type of mastoid process. The clinical course is quite different. In the osteothrombotic type, if operation seems urgent because of untoward symptoms and signs, nothing short of complete operation to nonbleeding bone will be effective. Incomplete operation will do more harm than good.

I hold a different opinion in regard to the urgency for operation in the subsequently reinfected middle ear. The fibrosis resulting from the previous infection may act as a good barrier to extension, although the subjective symptoms may be greatly increased because the swelling of the tissue in the confines of the cellular structure is more intense.

If one should immediately operate in every case that presented certain signs said to be significant of mastoid disease, it is difficult to see how clinical or surgical judgment could be developed or relied on, because the surgeon would never have observed the natural course of the disease.

No hard and fast rules can be laid down, as it is not a mathematical problem. Common sense combined with individualized surgical judgment will be the determining factor in choosing the optimal time for surgical intervention.

DR. JOHN F. FAIRBAIRN, Buffalo: Children's Hospital has 250 beds, and since March, 1926, there have been 694 patients admitted with acute mastoiditis who were operated on. There have been 8 deaths, as follows: 1 in a case of cavernous sinus thrombosis; 1 in a case of meningitis, twenty-four hours after operation; 4 in other cases of meningitis, and 2 in cases of pneumonia.

There was no case—there have been cases of scarlet fever in which my assistant or I operated—but I would say that as a rule there was no case in which an operation was performed sooner than two weeks after the onset, and in the majority of these cases operation was withheld until such time as nature flashed an alarm.

I feel that that is very concrete evidence to substantiate what the speaker has so well told us.

DR. HILL HASTINGS, Los Angeles: It is hardly necessary to discuss the paper except for two points: Some years one is persuaded that one must operate a little earlier than one would ordinarily, owing to the activity of the infecting organism in those particular years.

The other point is this: It has been my experience, and no doubt many have had the same experience, that some patients with acute infection of the ear running three or four days continue to have a high temperature, and especially the children will have at night what the mother thinks is delirium—probably due only to the high temperature—and there is an insistence on the part of the internist or the surgeon that one do a mastoidectomy. They have ruled out everything—abdominal disease, thoracic disease, endocarditis, pyelitis—so there is nothing but involvement of the mastoid left.

In 2 cases I was about to operate—in one I had the patient in the hospital—it turned out after the pediatrician and the internist examined the patient time and again that there was nothing there, that there was a little rough spot in one lung, and I decided to wait. In the morning the pneumonic process was evident, though up to that time there had been no signs or symptoms of pneumonia.

One should watch carefully for the deep-seated, unrecognized pneumonia. I also feel that if one operates on such a patient, as has been done in the past, pneumonia will develop and will be laid to the ether. I think in such cases it was not the ether but an unrecognized pneumonia from the beginning.

VARIATIONS OF AUDITORY ACUITY RELATED TO AGE. DR. L. M. POLVOGT, Baltimore.

This is a study involving the results obtained in audiometric investigation of the hearing acuity at various ages.

DISCUSSION

DR. MAX A. GOLDSTEIN, St. Louis: When a man is over 50 or over 60 there is depreciation in his hearing even though he has nothing the matter with his ears. Atrophic changes in all tissues of the body occur—in the eye, the muscle, the bone—but what of it? What is the significance of that in the pathology of the ear?

I wish some one would find out why that dip comes at 1024 in the audiogram. That would be much more significant. To me the audiogram is only a laboratory aid to the clinician's diagnosis, just as the microscope is to the determination of tuberculosis. I should not think of making a diagnosis of tuberculosis of the larynx or of any other part of the upper respiratory system simply on the absence of the tubercle bacillus in the sputum, nor should I think of making a diagnosis of the condition of an ear, pathologic in character, exclusively on the basis of an audiogram.

DR. GEORGE M. COATES, Philadelphia: Long before the audiometer was thought of, it was well known that in many persons of advanced age perception of certain tones or pitches was diminished and later lost. These losses were for the most part in the upper register and were accompanied by lowered bone conduction; in other words, there are the characteristic findings of a perceptive lesion. This presbycusis is possibly akin to presbyopia in aged persons, except that the latter occurs possibly only in eyes of a certain type. Possibly presbycusis occurs only in ears of a certain type, but what type is not known.

From the studies just reported one sees that the picture is not due to the diseases associated with advancing age or to endocarditis, and so forth, for the cases in Mr. Bunch's first series indicate that these diseases were excluded, and in the second series the curves were distinctly comparable with those in the first series. Also, the patients were selected as being not noticeably hard of hearing, though a few said that they did not hear as well as they did when they were younger.

DR. WILLIAM E. GROVE, Milwaukee: I do not agree with Dr. Goldstein that this type of study is useless. One knows that with advancing age hearing decreases, but is one cognizant of the fact that it decreases a certain amount on the average with every decade? One simply says that as one gets older one's hearing is worse.

Now, some are engaged in industrial medicine and industrial surgery, and the question frequently arises: Has an individual lost hearing as the result of an exudate? With studies of this sort, which give one a general idea of the depreciation of hearing by decades, one has a better chance of deciding whether or not the patient has lost hearing as the result of an accident, and to some extent at least to what degree he has lost hearing from that cause.

Dr. Edmund Prince Fowler, New York: There is just one point which I think should be brought out. These studies are valuable as showing the average trends, but one must not forget that there are a great many exceptions. The fact that a man is getting older does not mean that he is necessarily getting more hard of hearing.

In cases of arteriosclerosis and cardiovascular disease, conditions which presumably cause more rapid aging, the deafness does not go down necessarily.

Dr. Leroy M. Polvogt, Baltimore: There are a lot of things one says—for instance, "We all know that with advancing age we are getting deaf." Well, somebody has got to prove it. One cannot just say, "We all know it." One has to have some concrete example of it, and put it in the literature. That is the reason these things are pointed out from time to time.

It is not of much value in treating the patient. One is still puffing air into the ears because it is the only thing one has to offer, yet one knows that in some patients the tones, say, are 4096 and that those far down are out—one knows one is not going to bring those back by treatment, but when 1032 and higher tones are down a little, one still tries to help.

The Nasal Accessory Sinuses as Foci of Infection; Evaluation of Various Diagnostic Methods. Dr. W. P. Wherry, Omaha.

The usual method of discussing the various diagnostic aids is not followed. Instead the subject matter is discussed under three heads: (1) the identification of the pathologic changes, (2) the measure of the infection load and (3) the patient. In diagnosis one must know as nearly as possible what pathologic condition is present, how this condition is affecting the patient, and what the general mental and physical state of the patient is.

Relation of Infection of the Accessory Sinuses to General Medicine. Dr. Trevor Owen, M.B., Toronto, Canada.

If the human organism recovers completely from an acute infection its state was that rather of unpreparedness than of defectiveness. However, if a chronic inflammatory state exists, in spite of an adequate supply of blood and a good exit for waste products, the organization is truly and basically defective. These faults are due to hereditary, environmental and nutritional factors, knowledge of which is meager. In acute sinusitis the patient suffers from the same constitutional symptoms as in any acute infection. This is due to a diffuse cloudy swelling of all the tissue cells from their perfusion by blood containing a toxin on its way to be excreted or destroyed. But the absorption of bacteria growing in the sinus culture ground and their transportation alive to distant tissues to grow there and produce inflammatory changes must be accounted most uncommon. The type of case in which proper drainage of an antrum can be expected to produce recovery is that in which there is a clear history of an abrupt cessation of long continued health. As sinusitis becomes chronic it becomes more and more of local significance, and the absorption from the surface becomes of negligible importance. In speaking generally of foci of infection one would put the teeth first in importance, the tonsils a poor second, and the sinuses a most unsatisfactory third. Chronic sinusitis does not cause inflammatory lesions in the parenchyma of the lung or the heart muscle or valves, nor does it have anything to do with gastric or duodenal ulcer, cholecystitis, appendicitis, ulcerative colitis, nephritis, nephrosis, pyelitis, or primary or secondary anemia.

Arthritis in its various forms is the big field for desperate remedies, and in rheumatoid and osteo-arthritis, when polyarticular, the removal of the so-called foci of infection is a constantly discouraging experience. One feels that these foci of infection are a result rather than an additional cause of the constitutional defect. There is no doubt, however, that a grossly infected sinus will add a burden of toxemia to a patient suffering from another chronic complaint. The question of treating that sinusitis should, however, be judged on its own merits.

In hyperthyroidism foci of infection should be left alone until the problem of hyperthyroidism is solved. In retrobulbar neuritis and in toxic or infective neuritis of the third, fourth or sixth nerves, a sinusitis may be the etiologic point. In patients with chronic degenerative diseases such as arteriosclerosis and diabetes the focus should be treated conservatively. Patients who are subjects of allergy and who have vasomotor rhinitis and secondarily infected sinuses provide the large majority of nasal invalids, whose invalidism has resulted from repeated, well intentioned attempts to alleviate that condition. Their last state is far worse than their first, and the attempt to relieve ashma by radical treatment of sinusitis is worthless. This is also true, on the whole, in cases of "so-called chronic bronchitis," which in reality is a lesion of the parenchyma of the lung or bronchiectasis.

CONSERVATIVE AND RADICAL SURGICAL METHODS OF TREATMENT. DR. E. ROSS FAULKNER, New York.

The wise practitioner should be neither conservative nor radical but should base his treatment on the underlying pathologic condition. Acute conditions should be treated until they are thoroughly well, and this will usually be accomplished by conservative methods. Colds that hang on are best treated by mild shrinkage and irrigation of the nasal passages. When these remedies fail, if the patient's circumstances permit, one may advise another climate with general tonic treatment. Vaccines may also be given a trial. In persisting sinus conditions the choice of an intranasal or an external operation depends on the various factors in the case. In some instances intranasal operation is to be preferred; in others, external. In all cases the general health of the patient should be cared for.

DISCUSSION OF THE PAPERS READ BY DR. WHERRY, DR. OWEN AND DR. FAULKNER

DR. HARRIS P. MOSHER, Boston: The method of discussing diagnosis outlined by Dr. Wherry is satisfactory and up to date. The points stressed under the three heads are endorsed.

DR. WILLIAM MITHOEFER, Cincinnati: Dr. Owen mentions two important factors pertaining to diseases of the nasal accessory sinuses, namely, the constitutional characteristics of the patient and the fact that the nasopharynx is often the gateway for the infection which secondarily affects the nasal sinuses. The question of allergic arthritis is of considerable interest. I cannot agree with Dr. Owen when he says that chronic sinusitis has nothing to do with gastric ulcer, cholecystitis, etc., or when he says "attempts to relieve asthma by radical treatment of sinusitis are worthless."

DR. EDWARD C. SEWALL, San Francisco: The important thing brought out is the question of the relationship of chronic disease in the sinuses to disease elsewhere in the body. One should defer judgment on this important matter until one has learned to remove such foci of infection. I cannot see how the internist or the specialist can draw any inferences as to the relationship between chronic sinusitis and other diseases until chronic sinusitis is cured. Many speak of their operations as if these operations did what they intended them to do. I don't think the operations do, except rarely. I think the results are very poor. Dr. Faulkner has expressed the mattter fairly. If one is to operate, one should try to improve one's technic until some other technical means takes care of the operating technic.

DR. SAMUEL R. SKILLERN JR., Philadelphia: Dr. Mosher has shown in his excellent work on osteomyelitis of the frontal bone that the diploe and cancellus

are simply a sewer which carries off infection; either they become infected, the infection turning into osteomyelitis, or they carry the infection over into the body.

I think Dr. Owen is wrong when he says that the sinuses are a very poor third to the teeth. One can get just as much infection from an interosseous infection, just as much toxemia from an interosseous infection, as from the root of a tooth.

Dr. W. Likely Simpson, Memphis, Tenn.: To discuss Dr. Faulkner's paper, it seems to me important in simple operations on the antrum to make a large opening with cleancut edges and not to leave a lot of shreds hanging around, if one expects to do any good. This can probably be done best with a circular cutting punch. Traumatism to either the middle or the lower turbinate often defeats the purpose of the procedure.

The intranasal ethmoid and sphenoid exenteration can usually be done satisfactorily without the removal of the middle turbinate. The cutting of the attachment of the anterior end of the middle turbinate, as suggested by Halle, and beginning the exenteration with the removal of the agger cells, as suggested by Mosher and Halle, give a good approach to this region. Of course, it is well known that many ethmoid cells are overlooked and also that some cells cannot be exenterated owing to anatomic barriers.

The Caldwell-Luc operation has given me excellent results in most cases. The smaller the opening in the anterior wall the better, if all the teeth are normal, and by means of mirrors, even though the opening is small, a thorough operation can be done, but the operative time is necessarily prolonged. If the ethmoid and sphenoid sinuses are to be exenterated at the time of a radical operation on the antrum, the procedure can be facilitated if done by the transantral route. The ethmomaxillary group is often overlooked except by this route. At times some of the anterior ethmoid cells and some of the outlying ethmoid cells cannot be reached through the antrum. The exenteration of the sphenoid is especially satisfactorily carried out by this method. If there are no teeth, the entire anterior wall should be removed.

In the sphenoid sinus with a tendency to close with mucous membrane, scar tissue, and so forth, the removal of the septum of the sphenoid, also of the posterior part of the nasal septum and much of the floor of the cavity usually gives a good result.

I should like to emphasize that drainage only should be sought in acute and fulminating infections of the sinuses. In infections of the ethmoid and frontal sinuses, with complications such as orbital abscesses, periostitis or osteomyelitis, external drainage should be obtained without any attempt to do a thorough, complete operation. If an external opening with good drainage without closure is made, the prognosis is much better than if exenteration of the frontal or ethmoid sinus is attempted. If a thorough, complete operation is indicated, this should be done when all acute infection has subsided. Usually in one or two months this procedure is safe. Many a patient has lost his life by too much surgical work during the time of an acute infection.

Intranasal surgical intervention in the presence of complications such as periostitis or orbital abscess is not as good as external drainage, and this is especially true in children.

If the usual intranasal operation on the sinuses associated with the radical operation on the antrum has not been satisfactory, or if a very extensive marked sinus disease exists, or if there are anatomic barriers such as marked extension of the frontal and ethmoid sinuses, the conservative operative procedure is an external operation on these cavities. The attempt to exenterate marked extensions of ethmoid cells intranasally is anything but conservative.

Exenteration of the ethmoid, sphenoid and frontal sinuses through an external wound through which all parts of these cavities can be thoroughly inspected with the naked eye or by means of mirrors and through which all pathologic tissue can be removed with very little trauma to the bony wall of the cavities is much more conservative than most intranasal procedures. The operation can be satisfactorily done under general anesthesia, but to me local anesthesia makes the entire pro-

cedure much easier and safer. Analgesia obtained with scopolamine and morphine makes the approach much easier.

DR. TREVOR OWEN, Toronto, Canada: Now, we are all in agreement as to the difficulty in estimating what patients are going to be benefited. In a statistical study one cannot do that. It is only by careful investigation of each patient, that one can do that, but it must extend over many, many years, and I think Dr. Mithoefer has not put the matter quite fairly, because in questions of sinus infection in cases of gastric and duodenal ulcer, if these are followed over a number of years, with all other factors put in their proper perspective one finds that the results are not correlated with the improvement in the sinus infections; and after all, the majority of patients with duodenal ulcer never have sinusitis. Mucous colitis, on the other hand, is not a disease but a disorder, the same kind of disorder which is apparent in the sinuses, and quite likely they occur together.

Each patient is an individual problem, and it is only by the long history that one can come to any conclusions. The sinusitis that I mean—if a patient has a sinus which is discharging pure pus, I am interested in that sinus, but if he has a sinus which has some thickened mucous membrane and a few shreds of pus in the mucus, I am not sure that I am interested in that. Isn't that an academic sinusitis? From an internist's point of view, I am not sure that I am interested in that problem.

Of course, the whole thing is a matter of careful consideration in every case.

DR. E. ROSS FAULKNER, New York: I cannot say that I altogether approve of the ultraconservative attitude assumed today not only by the profession but by the entire lay body in regard to operations on the sinuses. All know that it is a very difficult surgical field, and all know that it is almost impossible to eradicate focal infections when all the sinuses are involved; on the other hand, I think the bad repute of surgical treatment of the sinuses comes largely from incomplete, badly done operations.

I should be glad, if Dr. Owen comes to New York, to show a goodly number of patients who have been benefited and many secondary operations in cases in which you would think there had been thorough attention, especially in cases of otitis, which Dr. Owen passes over, in which, when one cleans up the sinus, the result is nothing short of brilliant.

The results in asthma are not satisfactory, and yet some are very, very satisfactory, taken as a whole. A man has to be careful in the selection of patients with sinusitis associated with asthma, if he is going to operate, and there are a great many other things to consider. Opening an antrum is not going to cure an asthmatic condition if a lot of other sinuses are involved. It is just stirring up the infections and probably will do the patients more harm than good, but if one eradicates the diseased tissues as thoroughly as possible one will get brilliant results by operations on the sinuses.

BENIGN LARYNGEAL LESIONS PRODUCING HOARSENESS: DIAGNOSIS AND TREATMENT. DR. CHEVALIER JACKSON, Philadelphia.

The term "hoarseness" is defined and also such terms as "huskiness," "raucous," "strident" and "croupy." A large number of diseases, tumors and other pathologic conditions met with in the larynx are listed. Emphasis is laid on the point that a malignant lesion usually develops in a larynx which previously was the site of some abnormal, or benign, lesion. In the examination of the larynx, mirror inspection should be supplemented by laryngoscopy whenever indicated. A complete physical examination, laboratory test, and a roentgen examination of the chest and neck are advised.

The hoarseness produced by tobacco is due to an irritation of the tissues by the empyreumatic oil which results from the destructive distillation of the burning tobacco. Alcohol affects the larynx by producing peripheral vasodilatation in the laryngeal mucosa. Hoarseness results in many cases from vocal abuse, as in lectures, singers and those forced to talk in noisy places. The application of silver

nitrate to the larynx causes hoarseness. Potassium iodide taken internally produces an engorgement resulting in hoarseness.

The treatment of hoarseness depends on finding the cause and relieving it, if possible. In removing benign lesions from the larynx the excision should never extend into the normal tissue at the base.

AN ANATOMIC AND CLINICAL STUDY OF CENTRAL LESIONS PRODUCING PARALYSIS OF THE LARYNX. DR. A. C. FURSTENBERG, Ann Arbor, Mich.

The developments in laryngology during the past twenty years have added few, if any, basic or significant discoveries to what was already known. It is believed to be of value to consider the central connections of the laryngeal nerves, and this neuro-anatomy is presented in detail and correlated with pathologic changes seen clinically. The laryngeal nerves have bilateral cortical representation, so that a supranuclear lesion would have to be very large to produce bilateral spastic paralysis. Most central lesions involving the nuclei or infranuclear pathways give rise to unilateral flaccid paralysis.

Wednesday Morning, June 5, 1935

TREATMENT OF HAY FEVER AND HYPERESTHETIC RHINITIS BY IONIZATION. DR. LEE M. HURD, New York.

The nasal mucosa shows microscopic changes immediately after ionization. Zinc ions do not enter the tissues in any appreciable amount. There is marked clinical reaction of the nasal mucosa lasting about one week. Symptoms of hay fever disappear immediately after ionization in nearly all cases. Hyperesthetic rhinitis is symptomatically relieved in the majority of cases. The various types of machines used for ionization and the technics are discussed.

LATE CHANGES IN THE MUCOSA OF THE FRONTAL SINUSES AND NOSE IN DOGS FOLLOWING IONIZATION WITH ZINC SULFATE SOLUTION. DR. B. J. MCMAHON, St. Louis.

Ionization of the noses of dogs with zinc sulfate solution caused fibrosis of the subepithelial tissues. This was progressively more marked and well established in dogs killed at intervals of from eighteen hours to seven weeks following ionization. Ionization of the frontal sinuses caused a similar fibrosis as seen in dogs killed at from seven to twelve weeks, and marked hyperplastic bone changes were found in dogs killed at twelve weeks. The epithelial changes in the nose consisted in primary destruction and later regeneration practically to normal, and in the frontal sinuses, in an eventual transition to a cuboidal type over the areas of greatest destruction.

DISCUSSION OF PAPERS READ BY DR. HURD AND DR. MCMAHON

DR. A. M. ALDEN, St. Louis: Early in work with children my associates and I were forced to the determination of some basis on which dosage might be computed. The scheme at present is to give patients weighing less than 100 pounds (45 Kg.) a milliampere minute per pound plus 10 per cent, and patients weighing more than 150 pounds (68 Kg.) a milliampere minute per pound less 10 per cent. Patients whose weights fell between these two limits received a milliampere minute per pound. I have given as much as 170 milliamperes in each side of the nose without additional reaction.

All of the ionizations on children are done under avertin given on the basis of 90 mg. plus, when it is necessary, a very small amount of chloroform. This gives a quite satisfactory anesthesia.

I have had no experience with the use of a solution in the nose, but if the technical difficulties incident to its use can be removed, the use of a solution would

seem to be a distinct advance in that it would prevent the ciliary trauma which follows even the most careful packing.

The end-results Dr. Hurd has reported are about the same as others have observed, and I am quite sure that he will tell one that he has not as yet had to apologize to a patient for symptoms which might be referable to the mucosal trauma incident to ionization.

DR. RALPH A. FENTON, Portland, Ore: Dr. McMahon has in this contribution completed his accurate and scientific histopathologic experiments regarding the mucosal and submucosal results from so-called ionization with zinc sulfate solution.

Bombardment of the nasal mucosa by means of the galvanic current and a zinc electrolyte has been shown not to cause permanent change or damage thus far to the ciliated epithelium. In this respect, its effects resemble those of therapeutic roentgen irradiation of the tissues.

In my experimental studies on such irradiated membranes, I found at first a release of immune substances through the killing of round cells in the submucosal stroma with consequent mobilization of phagocytic connective tissue cells. The later changes exactly paralleled those shown here today, namely, a vast increase beyond the normal amount of fibrous connective tissue.

Now, if it is desirable to shrink the mucous membranes of the turbinates, tying them down to the underlying bones by fibrotic bands which will grow stronger as the years go on, well and good. One has, however, seen the late effects of excessive fibrosis due to other sorts of cauterization. Let one think well whether it is wise to risk destruction of the vascular defensive apparatus and of its sympathetic nerve endings without changing the patient's specific allergic sensitiveness as demonstrated by skin reactions or eosinophilia.

Dr. McMahon's attitude of scientific detachment remains in marked contrast with the indiscriminate enthusiasm for this potentially dangerous procedure manifested by some of its proponents. I pointed out the danger respecting roentgen irradiation of the tissues in careless hands two years ago. Already commercial organizations are utilizing the communications of the members to bolster up their selling campaigns. One must not forget that these unnecessarily complex instruments for applying a simple current are readily obtainable by the irregular practitioner and the conscienceless charlatan.

Let me express the hope that Dr. McMahon may secure, within a year or two following this procedure, some human tissue for study and for dispassionate analysis of the existing allergic reactions at that time as well as the alterations in the vascular stroma by which the epithelium is nourished. He is entitled to heartiest thanks.

DR. JOHN J. SHEA, Memphis, Tenn.: When Dr. Warwick started his presentation on ionization, I was interested. Those who live in the Southwest have a long season of pollen. In the country below Memphis this season with certain pollen is as long as nine months, and the patients with vasomotor rhinitis make up a good proportion of the unsatisfied patients, so in order to test out the efficacy of Dr. Warwick's treatment, one of my fellow townsmen, Dr. Blassingame, went down to get the technic from Dr. Warwick himself, and three or four of us chipped in and got machines to try out and to see what we could do.

Now, we have not yet compiled our local results in Memphis, but I will say that the men who are trying ionization feel that they have satisfied the patients who were treated during the hay fever season.

The patients who claim the best results are those who are treated after their hay fever starts. There is one day of intense nasal obstruction that can be controlled by a moderate amount of sedatives; then, in three or four days, the nose begins to open up and the mucous membrane changes from the pale vasomotor color to what is a normal pink to the eye, and for the rest of the pollen season the patient is comfortable, if a good ionization has been done.

I have had the opportunity of taking tissue from only 1 patient with a vasomotor condition. I think there is a difference in the reaction to ionization in the membrane of such a patient and in that of a dog that has not had this defensive process going on for years.

Dr. Lyman G. Richards, Boston: I should like to speak of this question of utilization of a solution rather than packing. If ionization is to become a satisfactory procedure, eventually one is going to come to some form of complete flooding of the nasal surface. This is particularly true in children, and I have worked to some extent with this method. It can be accomplished, I believe, by the utilization of a postnasal pack tightly fitted in and tightly covered with oiled silk and a layer of iodized poppy-seed oil 40 per cent or of some other substance. I have found it extremely difficult to get surface packing of the nose with this cotton, particularly in children. I was deceived as to the ease with which one can satisfy the requirements stated to be necessary in respect to the amount of milliamperage. It is stated on the machine to be somewhere below 3,000. I have repeatedly packed a nose and felt somewhat dissatisfied with the application of cotton to cover the surface of the nose, especially on the middle turbinate and somewhat deviated sections of the septum, and, after a moment's trial of the machine, I have found it difficult not only to get the milliamperage below 3,000 but to get it within the range of 1,500 or below that, yet I am morally certain that I have by no means covered the entire surface membrane, and that is supposed to be the requirement.

Some of Dr. Warwick's illustrations show the complete pack, but in the child, particularly, I have found it almost impossible to get a complete covering; the deviations of the nasal septum are such that it is almost impossible to do that. I believe it to be far simpler to find some satisfactory method of occluding the choana by local anesthesia or by some form of postnasal balloon. It would be simpler to flood the nose with the solution and then set the electrode loosely and continue with the ionization.

The packing itself is a tedious and unpleasant procedure for the patient, and I believe a modification of this, if one believes in the procedure, will become very useful.

Dr. William B. Chamberlin, Cleveland: This method, if successful, will certainly be a boon to those with patients who come during the hay fever season. Granted that these patients might be benefited or in some cases even cured by inoculation, time and experience have well proved that inoculations given after the beginning of the attack of hay fever are of no value.

Now, there was a point which Dr. Hurd mentioned on which I, at least, would like to have further enlightenment from the men who have had clinical experience with this procedure.

Dr. Hurd mentioned anosmia. His remark concerning that to me is significant, and I should like to know the experience of Dr. Alden, Dr. McMahon and others who have had experience with a number of clinical cases as to whether or not they have encountered anosmia, and, if they have, how long the anosmia continued or if it has been permanent.

Certainly, if one is going to get permanent anosmia, it is a vital contraindication to the use of the method.

Dr. Joseph C. Beck, Chicago: One must agree that there is a great difference between experiment on a dog and treatment of a human being, yet as to vascularization the changes that were shown by Dr. McMahon will not differ whether they are in a pathologic preparation, a normal one or an animal; in other words, one knows what follows in a persistent vascularization, as it was shown in these animals —that one should expect certain changes around the glandular elements and nutritional elements in the tissues, and it is too early, as far as this matter has gone, from the time Dr. Warwick presented his material to this day, to see what is going to happen.

Did Dr. McMahon make a control of the other sinus, not by ionization, but by application of a surgical procedure such as irritation, packing, or whatever

it might be, and see what change was there, so that one would not be comparing a normal sinus with one that was ionized?

I want to state here something that I have done regarding the suggestion by Dr. Richards, that is, using the fluid and inflating the postnasal space to occlude the postnasal choana. Through a tube you can do this much more easily than with tampons, and, with a child, using postnasal tampons is about as bad as packing or an operation.

This tube is made of quite resistant rubber. The idea is not original. A former otolaryngologist in Chicago—at this moment I have forgotten his name—used the tube, trying to stop a hemorrhage following an operation for adenoids in the old days, and I have taken it and remodified it, and I will put it out as soon as I know it is fit.

Dr. Hurd quoted a Chicago man, of the University of Illinois, Hollender. He mentioned his name so I will mention it. This man has charge of the physiotherapy at the University of Illinois, and I have seen some preparations—I should like to have you withhold till a little later any report that has been made regarding that statement by Dr. Hurd as to the old specimens, old preparations, that have been presented at the state meeting in Illinois, because I was not present there, and I believe it may be of some value. Dr. Hurd, when he writes his paper, could include those publications. They may be of value because the matter goes back as far as twelve years.

Dr. Lee M. Hurd, New York: He said no epithelium recurred.

Dr. Joseph C. Beck, Chicago: Yes. I saw those, some of those, preparations.

Dr. Charles D. Blassingame, Memphis, Tenn.: I have treated about a dozen noses by ionization and my experience has been satisfactory.

In regard to anosmia, a patient whose nose I treated by ionization says that she has lost her sense of smell, but she says that this condition is preferable to hay fever, and she is not objecting to the loss of smell.

I do not know but that one might avoid this complication if one did not pack in the roof of the olfactory recess.

Dr. Samuel R. Skillern Jr., Philadelphia: I want to ask Dr. McMahon whether in packing the frontal sinus he packed actually into the frontal sinus or whether he packed simply through the nose. In Philadelphia we have found what we think is a new condition. I read a paper on it before the American Laryngological Association—on obliterative frontal sinusitis from a proliferative osteitis.

Now, then, if ionization through the nasal chambers will in twelve weeks' time start proliferation of new bone in the frontal sinuses, is one going to get complete filling of the frontal sinuses with the new bone growth? If one does, one will get walled-off foci of infection, because, as those sinuses narrow down, if infection occurs, it will stimulate further bone growth, and one will get interosseous infections which are difficult to diagnose and which require the most radical surgical intervention; so, I am wondering whether, if just the removal of frontal ethmoidal polyps starts up this proliferative osteitis, ionization is going to do the same thing. If it does, one cannot use fluids; one will have to stick to packs, because the fluid will certainly get into the sinuses and start proliferative osteitis.

Dr. Thomas C. Galloway, Evanston, Ill.: This subject is apparently under consideration by the American Medical Association Laboratories. We had a little discussion by Dr. Leech, who is the physicist, and he said, in the first place, that ionization is not essentially different probably from the introduction of a more concentrated solution. He said that perhaps the use of a 2 per cent zinc sulfate solution in ionization is the same as having a 20 per cent solution in contact with the mucosa, and it is possible, he thinks, that this treatment will be reduced to a much simpler procedure.

He said also that he can see no physical reason why a combination of metals for electrodes is of advantage over zinc alone.

I wish some of the speakers who have considered the theoretical aspects of the matter could explain exactly how ionization works. Is it by the destruction of the

absorption surface for allergens? Is it by the introduction of the reflex arc, or is it by a diminution of or other effect on the blood vessels themselves? I wish one could have some scientific work on that subject.

Dr. Lee M. Hurd, New York: Dr. Titus of New York has over a long period of time treated hay fever by the ultraviolet rays, and he has secured relief in 97 per cent of the cases.

I cannot remember the name but I know a man who packs the nose and raised the temperature and obtains relief for his patients.

I have a few patients who have been treated with x-rays who had hyperesthetic rhinitis, and I saw a girl the other day who had been free about three years in whom lately the condition has recurred.

The flooding game is pretty and nice, but the result is anosmia! It scares me to death. I have had eight or nine or ten weeks of it. One woman has paranosmia now.

Now, another point: If one knocks out the olfactory nerve, one knocks out the sensory nerves of the nose at the same time, and that is the reason the patients do not have symptoms.

As far as this flooding goes, it is much easier to do it in just the opposite way. I have a nasal tip and a piece of rubber tube put in the nose like that, and have a piece of string here, and the patient holds it right there; one sees the water level here, the electrolyte level. When the nose is full on that side, it will run out on that side, and one is ready. The level is here, and one watches it and sees it go up and down.

What I am trying now is packing olfactory clefts with petrolatum and gauze to see if they can be occluded from the ionization.

About the combination of metals, I think that has been settled. There is no tin. Professor Muller of New York University examined the first lot and found no tin, and Dr. Goldner, one of the leading chemists of New York, telephoned me the night before last with regard to that last batch of electrolytes the formula for which has been put on the ampule.

I have used some of the vertical electrolyte on one side and zinc sulfate on the other side and see no difference on the two sides now.

Dr. Bernard J. McMahon, St. Louis: Dr. Shea's slides brought out that the changes in the mucosa are the result of trauma, whether this arises from an operative procedure, zinc sulfate, phenol, or whatever other type of irritant you wish to use. The reaction of the tissues to excessive handling is a fibrosis; it is in the connective tissue reaction that one is interested, and his side showed a definite connective tissue reaction, fibrosis. That follows any irritation.

The solutions were used for the reasons which I outlined, and the frontal sinus mucosae were not changed. Of course, the specimens were sectioned all the way through, the frontal sinuses were taken with the nose, and the sections showed no change in the mucosa. I do not see why one should be afraid of going up into the sinuses as long as one has no displacement of air in the sinuses, as proved by Dr. Proetz' work.

I cannot answer the question about anosmia. I have had no clinical experience with ionization. I do not feel justified in following it out yet. I can easily see, however, why anosmia would occur, because it is a known fact that the ions of the heavy metals destroy the nerve endings; whether that is permanent or temporary, no one knows; no one has followed the cases for a long enough time.

I think it is possible that ionization may have a direct use and be valuable, because some solution may be worked out which will replace the salts lacking in the tissues of the nose or change the reaction, not forgetting that allergic rhinitis is only a local manifestation of a systemic dyscrasia.

As to Dr. Skillern's question, I evidently did not make myself clear. I did not pack the frontal sinuses. A window was removed, the sinus was filled with solution, and the electrode was introduced into the solution. The walls were not touched. I do not want to convey the impression that the hyperostosis was the

result of the ionization. It simply followed the ionization in 1 case, showing that an extreme irritation has an effect on the deeper tissues, on the connective tissue, as well as on the bone.

DIFFERENTIAL DIAGNOSIS OF ENLARGEMENT OF THE LYMPH GLANDS OF THE NECK. DR. R. F. FARQUHARSON, Toronto, Canada.

The diagnosis of enlargement of cervical lymph glands is usually made without difficulty on the basis of the history and the results of the clinical and hematologic examination alone. A biopsy is often helpful but, unfortunately, the histologic picture is not always decisive. Tuberculosis usually develops in glands high in the neck near the angle of the jaw. In Hodgkin's disease most commonly the supraclavicular glands on one side are involved first. The spleen is usually palpable from the first, whereas this is uncommon in tuberculosis. Tuberculous glands are commonly tender, while those involved in Hodgkin's disease are not. Lymphosarcoma commonly begins in a tonsil or in adenoid tissue of the pharynx. Cervical glands may be secondarily involved in carcinoma of the nose and throat or by infections of these areas. Carcinoma of the stomach may be associated with enlargement of a gland on the left side of the neck above the head of the clavicle.

In patients with generalized involvement of the lymph glands, one must be careful not to confuse the condition with infectious mononucleosis, which is never serious, or with acute leukemia, which is always fatal. The differentiation is clearly made by clinical examination and by study of the blood picture. Chronic leukemia, syphilis and German measles must also be differentiated from this condition. In syphilis the glands are small, firm, freely movable and not tender.

DISCUSSION

DR. C. STEWART NASH, Rochester, N. Y.: Dr. Farquharson has presented a cleancut differential diagnosis of enlargement of the lymph glands of the neck, and the members are indebted to him for renovating this subject matter. Every otolaryngologist has in reserve some scheme of differential diagnosis of enlargement of the cervical glands which he brings forth as the occasion demands, but it is particularly fitting that this subject matter should be presented from the broader point of view of general medicine.

This paper is not controversial; one accepts the statements as facts. There are, however, two comments I wish to make. In the first place, Dr. Farquharson has not taken into his differential diagnosis agranulocytic angina, which sometimes produces associated cervical adenitis, and which in at least 1 case presented a problem of differentiation between mononucleosis from an infected lung and agranulocytic angina. Secondly, in his paper he makes the following statement: "Occasionally a large hard sentinel gland above the head of the clavicle, usually on the left side, is a helpful sign of carcinoma of the stomach which formerly may not have been suspected." To me this sign is both interesting and unique. If sufficiently dependable, it gives the otolaryngologist an opportunity to make a very clever diagnosis of a malady somewhat astray from his own particular field.

DR. LYMAN G. RICHARDS, Boston: I should like to make one further addition in connection with certain congenital anomalies in the form of branchiogenous cysts. These not infrequently cause difficulties in diagnosis and from time to time simulate enlarged cervical glands; and, finally, I should like to speak of differential diagnosis between cervical gland infections and signs and symptoms of these in conjunction with lateral pharyngeal abscesses in the neck.

Frequently one sees a pharyngeal abscess located behind the posterior pillar of the tonsil and situated lateral to the constrictors of the pharynx, occupying somewhat the region known as the pharyngomaxillary fossa. An abscess in this region, particularly in the younger boy from 8 to 10 years of age, often presents a diagnostic problem. The classic appearance is that of a swelling along the lateral pharyngeal wall, but frequently in conjunction with that there is an external swelling in the neck. It is somewhat difficult at times to estimate the significance of

this external swelling. If it is regarded as part of the pharyngomaxillary infection, there is naturally a temptation to approach this surgically by the external route.

However, the external swelling, in my experience, is not infrequently due to a secondary glandular enlargement entirely apart from the abscess; therefore, it has been found important to differentiate this condition by watching carefully the appearance of the lateral pharyngeal wall.

In case this infection begins to show prominence and bulging in this region, as it frequently does, the internal approach with incision and drainage from within the mouth will almost invariably evacuate the pus, and external incision will not be required.

If external incision is made to the acute swelling on the outside, and this swelling is due to an acute cervical adenitis, disastrous results will follow. If, however, the condition is treated and the pus drained from the inside, almost invariably the acute glandular swelling, the swelling on the outside, will subside of itself and not require incision.

This differential point, I think, is a very important one.

Dr. Frederick T. Hill, Waterville, Me.: In this admirable comprehensive differential diagnosis I think one should keep in mind, in addition, the possibility of a neoplasm in the nasal pharynx and the importance of routine laryngeal examination as well as the possibility of chronic lingual tonsillitis, especially in patients who have been tonsillectomized.

Dr. Thomas E. Carmody, Denver: I compliment the society on having a paper of this kind presented to it. One of the points brought out I do not exactly understand. Dr. Farquharson spoke of carotid and submaxillary tuberculous infection.

Some years ago I reported 2 cases of tuberculous infection of the carotid gland, one of them bilateral. At that time I could find published reports of only 11 cases. In one of the cases which I reported the disease was terminal, and in the other it was far advanced.

I want to ask which of the cases referred to by Dr. Farquharson were primary and which were secondary. I do not understand why the condition cleared up so quickly—if I understood him correctly.

Another point one must consider, and Dr. Farquharson covered it, is that of the infection from the nasal pharynx. There may be present some infection besides that which one is trying to diagnose, because even with a differential diagnosis one may see engrafted on top of the tuberculosis a suppurative infection or something of that kind. One finds quite often that infection of the carotid and submaxillary glands comes from the tonsillar region and also from the nasopharynx.

Very frequently one is at fault in not making a complete examination of the nasopharynx. Dr. Hill has spoken of that and also of the lingual tonsillar region.

This year in Denver there have been a number of complications with German measles or the so-called three day measles, and many of these complications, I believe, were not German measles or measles at all, but were scarlet fever. Frequently one sees scarlet fever with the rash disappearing suddenly, and all the sequelae of scarlet fever and the enlargement of glands may come from the infection in the throat or from an infection of some other type.

Dr. Richards brought out a good point: that infection of the pharyngeal maxillary space can frequently be found inside and that the incision can be made inside, with fairly prompt recovery; when one makes the incision outside one may have many complicating symptoms.

Dr. Ray Farquharson, Toronto, Canada: I am grateful to Dr. Nash for bringing agranulocytic angina to attention in differential diagnosis. It is extremely serious and is associated with gangrenous angina of the throat, secondary enlargement of glands high in the neck and a very low white cell count.

As far as the sentinel gland is concerned, every once in a while one makes a diagnosis of what is wrong with a patient who is seriously ill and in whom there is a carcinoma of the stomach without definite gastric symptoms.

As regards Dr. Richards' branchiogenous cysts, I confess complete ignorance of them and am glad to hear of them. I am sure those who deal with the nose and throat will think of them long before I shall have occasion to do so.

In connection with syphilis, occasionally a gumma, especially one involving the sternomastoid muscle, may be confused with a lymph gland, but not with an enlarged lymph gland. As to the cases of uveocarotid tuberculosis to which I referred—no report of these cases has been published, but there was a fairly complete review of the condition in the *Lancet* during the past year. I do not wish to give the impression that the patients recover quickly. Many of them have recovered spontaneously over a long period of time. The first patient whom I saw had tuberculous uveitis, following which there came a large swelling of the carotid and submaxillary glands, and the glands were excised—the carotid and submaxillary glands, or part of them, were excised—but a number of cases have been reported in which the condition cleared up spontaneously.

It is important, as Dr. Carmody remarked, to look for complicating infections. The subject is broad and it is difficult to cover it all.

OSTEOMA OF THE NASAL ACCESSORY SINUSES. DR. T. E. CARMODY, Denver, Colo.

Figures indicate that this condition is more common in young persons. The etiology of the condition is truly controversial. The tumors usually grow slowly, and there is great divergence in size and involvement. The symptoms are (1) external deformity, (2) headache, (3) cerebral paralysis, (4) discharge and (5) vertigo. There does not seem to be any definition of the direction or of the possible extension. The treatment is undoubtedly surgical. Since no one operator has had a sufficiently large number of cases to allow evaluation of the various methods of surgical procedure, the method must depend on the particular case. In this paper 6 cases are presented, and 139 cases reports of which were found in the literature have been tabulated.

DR. WILLIAM B. CHAMBERLIN, Cleveland: To go over the situation briefly, there are apparently five theories as to the origin of osteoma of the frontal and ethmoid sinuses, each of which has its enthusiastic proponents and each of which is vigorously opposed by the champions of other theories:

1. The osteoma originates from fetal remains of cartilaginous tissue, the ethmoid sinus being laid down in cartilaginous tissue, the frontal sinus in connective tissue. Against this theory is the fact that no remains of cartilaginous tissue have been found in any osteoma which has been removed. This theory is championed by Arnold, von Rokitansky and Boenninghaus, who see a parallel between the osteoma and the exostosis of the long bone, which usually occurs at the epiphysis.

2. The origin in the periosteum is vigorously supported by the French school, notably Sappey and Dalveau, as well as by Bornhaupt, Tauber and Zuckerkandl.

3. In support of the diploic origin, Chapman reports a case of anosteoma with a small pedicle arising from the diploe above the frontal sinus.

4. Others advocate the possibility of suppuration within the frontal sinus as a causative factor. I think the suppuration is secondary and due to blocking.

5. Trauma plays an important part.

If one can draw any conclusions from the literature, osteoma of a frontal or of an ethmoid sinus must be fairly rare. Gerber in 1907 found only 87 reported cases. To these Harris in 1928 added 28 others, 2 of them being his own. Armitage reported them as occurring more frequently in males than in females, and 80 per cent before the age of 50. By far the most frequent incidence is in young persons in the second and third decades of life. This is the age during which trauma is most likely to occur.

DR. JOSEPH C. BECK, Chicago: In the few years I have been in practice, including my clinical experience, I have encountered 4 cases, just 4 cases, of osteoma of any considerable size. I do not mean cases of exostosis or osteogenesis

or anything like that, just histologically proved cases of osteoma. Osteomas have a distinctive histologic appearance.

The traumatic theory holds well and is the nearest approach, although almost everybody gets a bump at some time or other in his life and one cannot call that an osteoma.

I want to speak about a practical application which may be useful to some. In a case of osteoma that has come under my observation since I reviewed Denker and Kahler's record of the osteomas that have been collected the world over, I was fooled by the x-ray picture. If I had taken an exterior view, as one should in cases of this type, I would not have been fooled, and if I had listened to the radiologist I would not have been fooled, but I went ahead, operating on an osteoma of the frontal sinus, sure that there was a perfectly normal posterior wall of the frontal sinus and a space between the tumor and the posterior wall. When I went down and took away part of the dura that was involved in the tumor and had an exposure of the brain over an area 1¼ inches (about 3 cm.) in size, the regular size for exposure of the frontal region, there was no evidence of suppuration. It was a normal sinus.

I was fearful of secondary meningitis. The sphenoidal tumors, the osteomas, that is, are inoperable. It is better to leave them alone than have meningitis develop. That is the consensus, and yet there has been heard in this discussion the report of a clearly removed osteoma of the sphenoid.

Now, in this man I immediately covered the frontal lobe, the exposed brain, taking a big piece of fascia lata, and laying it over the exposed brain; I put over it a piece of gutta percha, and on top I put iodoform gauze, and four days later I removed this pack and made the final closure.

Dr. Robin Harris, Jackson, Miss.: My object in going through the literature in all languages was to try to arrive at the etiology. I failed.

Dr. Thomas E. Carmody, Denver, Colo.: There is little to say. The matter has been covered by the discussers, and I wish to thank every one of them.

I shall have to admit that Dr. Chamberlin's growths are much larger than any of mine. I guess they grow larger in Ohio.

Referring to Dr. Beck's covering the dura—I did not do that, and there is a possibility that that accounts for the epileptic form of convulsion in the case. I thought the convulsion was due to the fact that the growth in the sinus had gained entrance and that there was back pressure on the brain, but the possibility is that the patient was tired. One finds an epileptic form of convulsion coming on when the patient is tired.

I want to apologize to Dr. Fenton for not discovering a case of his that was reported. In the patient I referred to there was no double vision before operation. He did have it shortly after, but promptly recovered.

The Middle Ear Muscle Reflex in Response to Acoustic Irritation. A Motion Picture Film. Dr. H. G. Kobrek, Chicago.

In recent years a great deal of work with animals has been done in the study of otologic problems. A variety of indicators of hearing are in use to determine the hearing ability of the experimental animal. The prima reflex, conditioned reflexes and electrical findings, the so-called Wever and Bray phenomenon, may be mentioned.

The acoustic contractions of the intrinsic muscles of the ear, in the tensor tympani and in the stapedius have been known for many decades, but only in recent years has it become evident that these reflexes may be used as a reliable indicator of hearing in the animal experiment. The reflex has been observed also in suitable cases in man, and a comparison can be made between the hearing sensation and the reflex response.

Book Reviews

Speech in Childhood: Its Development and Disorders. By George Seth, M.A., B.Ed., Ph.D., and Douglas Guthrie, M.D., F.R.C.S. (Edin.). Price, $3.50. Pp. 224, with 46 illustrations. London: Oxford University Press, 1935.

Seth and Guthrie point out that the problems of defects of speech are by no means negligible. Available statistics show that about 3 per cent of the total school population suffer from defects of speech and that approximately one third of the children showing more or less pronounced defects of speech are stutterers, the defects in the remaining number being distributed over the various difficulties of articulation in which the sufferer is unable either to pronounce or to pronounce clearly certain sounds or combinations of sounds.

The book falls into two parts. The first part covers a consideration of the nature and development of speech and the function of speech—its physiologic, phonetic and psychologic aspects. It concerns itself with the basal knowledge of the mechanism of sounds and the acquisition of normal speech. In the second part the influence of defective hearing on speech is discussed, and the commoner speech disorders—lalling, nasal speech, stuttering and the like—are described.

The text is illuminated by numerous schematic drawings, forty-six in all.

Every otorhinolaryngologist has an interest in the problems of hearing and speech, and to these this volume will be an aid in throwing light on the problems of defects of speech.

Radium Treatment of Skin Diseases, New Growths, Diseases of the Eyes and Tonsils. By Francis H. Williams, M.D. Price, $2. Pp. 118, with 12 illustrations. Boston: the Stratford Company, 1935.

Part I of this brochure is a brief discussion of the nature and properties of radium, the measurements used, the methods of applying radium and the use of radium in diseases of the skin and superficial new growths. Part II discusses radium in diseases of the eye; Part III consists of a plea for the use of radium applied to the faucial tonsils and other lymphoid tissues of the throat. The arguments remind one of those put forth so enthusiastically for the use of diathermy in the removal of tonsils, which have proved to be more fallacious than justifiable.

Directory of Otolaryngologic Societies *

FOREIGN

COLLEGIUM OTO-RHINO-LARYNGOLOGICUM AMICITIÆ SACRUM

President: Prof. Gunnar Holmgren, Karolinska Mediko Kirurgiska Institut, Stockholm, Sweden.
Secretary: Prof. Dr. C. E. Benjamins, Verlengde Heereweg, 143 Groningen, The Netherlands.

NATIONAL

AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON LARYNGOLOGY, OTOLOGY AND RHINOLOGY

Chairman: Dr. Ralph A. Fenton, 1020 S. W. Taylor St., Portland, Ore.
Secretary: Dr. Gordon B. New, Mayo Clinic, Rochester, Minn.
Place: Kansas City, Mo. Time: May 11-15, 1936.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Wells P. Eagleton, 15 Lombardy St., Newark, N. J.
President-Elect: Dr. Frank E. Burch, 408 Peter St., St. Paul.
Executive Secretary: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.
Place: New York. Time: October 1936.

AMERICAN BRONCHOSCOPIC SOCIETY

President: Dr. H. M. Taylor, 111 W. Adams St, Jacksonville, Florida.
Secretary: Dr. Lyman Richards, 319 Longwood Ave., Boston.

AMERICAN LARYNGOLOGICAL ASSOCIATION

President: Dr. Burt R. Shurly, 62 W. Adams Ave., Detroit.
Secretary: Dr. James A. Babbitt, 1912 Spruce St., Philadelphia.
Place: Detroit. Time: May 1936.

AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY, INC.

President: Dr. Thomas E. Carmody, 227, 16th St., Denver.
Secretary: Dr. R. L. Loughran, Sharon, Conn.

SECTIONS:

Eastern.—Chairman: Dr. Frederick T. Hill, Professional Bldg., Waterville, Maine.
Southern.—Chairman: Dr. Beverly R. Kennon, Medical Arts Bldg., Norfolk, Va.
Middle.—Chairman: Dr. Daniel W. Layman, Medical Arts Bldg., Indianapolis.
Mid-Western.—Chairman: Dr. Harry W. Lyman, Carleton Bldg., St. Louis.
Western.—Chairman: Dr. Frank A. Burton, Bank of America Bldg., San Diego, Calif.

AMERICAN OTOLOGICAL SOCIETY

President: Dr. Francis R. Packard, 304 S. 19th St., Philadelphia.
Secretary: Dr. Thomas J. Harris, 104 E. 40th St., New York.

* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.

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